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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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Forthcoming Events.

JANUARY 22.

Sheffield Metallurgical Association:—Ordinary meeting at Sheffield. "The Application of Electro-deposited Metals to Engineering," Paper by C. H. Faris.

Institute of British Foundrymen.

JANUARY 19.

Birmingham Branch:—Annual dinner at Birmingham.

Scottish Branch:—Ordinary meeting at Glasgow. "Some Notes on Patternmaking," Paper by R. Ballantine and J. Delaney.

Lancashire Branch (Burnley Section):—Annual social at Burnley.

JANUARY 25.

London Branch (Junior Section):—Ordinary meeting in London. "How to Become a Foundry Foreman," Paper by A. F. Gibbs.

JANUARY 26.

East Midlands Branch:—Annual meeting. Short Paper Competition at Loughborough.

Newcastle and District Branch:—Ordinary meeting at Neville Hall. "Coal Dust: Its Use and Abuse in the Foundry," Paper by B. Hird.

Metallurgical Research.

We were much struck a few weeks ago on hearing a prominent foundryman say, in expressing his doubt of the results of a piece of practical research, that we had first of all to "know more about cast iron"—that is, to do more fundamental research first.

Of all the questions that are apt to arise in the relationship between Science and Industry, none is more vexed than the query as to what should be done next in scientific research. We have referred, on many previous occasions, to the views of the practical and the scientific man; how each party is limited by training, experience and point of view, so that the scientific man will often condemn, as the mere solution of a practical problem, work that the average industrialist must regard as highly abstruse and incapable of direct application. Nowhere are these difficulties more keenly felt than in the relations between the research associations on the one hand, and on the other hand, firstly, the leaders of scientific research in their particular field, and secondly, the industrial men for whose benefit they are bound to exist. Their function is to bridge the gap, but the right way to do so is not always clear.

The research associations—and we are of course considering primarily the two metallurgical research associations, the C.I.R.A. and the N.F.M.R.A.—are apt to find themselves impaled on the horns of a dilemma. If they undertake problems fundamental enough to please the scientists, their own members are apt to question its direct usefulness to them; if they give their programmes a sufficiently practical tinge to please the men in the industry, they are promptly taken to task by the scientific group.

The most recent criticism takes the line that the metallurgical research associations are conducting researches that are not sufficiently fundamental to be in the interests of the industry or of the community at large. It has even been suggested that the fact of Government support of research associations has been made an excuse for the refusal of further support for other and more fundamental research work designed ultimately to benefit industry.

It is commonly forgotten, however, and we feel it essential to emphasise the fact, that the Government's total expenditure on metallurgical research must be ten times as great as the sum allotted to the two metallurgical research associations together. The great bulk of this expenditure goes, in fact, not to the research associations, but to such institutions as the N.P.L., which are devoted primarily to the pursuit of fundamental research. If, therefore, such researches as those of the C.I.R.A. are liable to criticism in scientific quarters as being of too highly practical a nature, it seems not unreasonable to reply that plenty of fundamental research work is being carried on at Government expense under other auspices. If the scales are weighted on one side or another it is assuredly on the side of so-called fundamental research.

Pulverised Fuel and the Coal Dust Manufacturers.

Our esteemed contributor, "Marksman," was not on the target when he suggested that the collieries should manufacture at the mines powdered fuel for the smaller furnaces used in foundry practice, because there are a number of high-grade firms which have installed at great cost plant specially designed to produce coal dust of various grades. These firms have so arranged their establishments that to-day there is at least one factory in every important foundry centre in Great Britain. Thus, though there is still the cost of getting the raw coal to the factory, there is the countervailing advantage of a small haulage from the factory to the consumer.

The coal-dust manufacturers have either instituted or are installing commendable scientific control over their products, and they are now in a position to meet the foundry organisations for the preparation of standard grades. In fact, they are already supplying certain of the more erudite foundries to specification. If this business were transferred to the collieries we are convinced that the foundry industry would suffer. The coal-dust people at present have the advantage of many sources of supply; the moment one particular seam shows signs of deterioration they can transfer their business to another. Exactly parallel conditions are to be associated with the provision of powdered fuel for industrial furnaces. The ash, fixed carbon and volatile contents of powdered fuel require, in the case of certain types of burners, to be closely controlled, and we submit that the organisations established for the provision of coal dust for the grey-iron foundry industry require but a minimum of orientation for successful and economic supply of powdered fuel for small industrial furnaces.

As a final word, we tentatively put forward the notion that to obtain the best results from the use of pulverised fuel a blend of a number of types of coal may be found in the long run to give the best results. If this be the case, then its manufacture is obviously best left in the hands of people well versed in this particular branch of industry.

XUM

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Cambr.dge Engineering School.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—I notice in your issue for December 27 that you refer to Engineering School at Cambridge University. I think that your statement, "her engineering is little," hardly does justice to the situation.

Cambridge has an Engineering School of quite a considerable size, and the new laboratories—which have been in use now for about six years—will bear comparison, in my opinion, with those of any other universities. I am not competent to speak of the situation on the metallurgy side, as I personally did not include metallurgy in my studies, but a good course is open to students, and I believe the laboratory accommodation is being increased.

It should be recognised that Cambridge does not try to turn out practical engineers. The aim is to lay the foundations of a thorough education in the theory of all branches of engineering. Specialisation is only permitted in the final year of the Honours Course, and is then not confined to one subject. The practical work done in the laboratories and drawing offices is intended to supplement and emphasise the class work; it does not cover in the least the type of work the student will do when he starts in a factory. The place for practical engineering experience is the factory, and it is, I feel, a waste of time on the part of the University to attempt to impart such experience in the academical atmosphere prevailing there.

For example, a student at Cambridge does not learn how to design a bridge, let us say. He will learn that in the office of the engineering firm to which he is apprenticed. What he does learn is the mathematical theory of bridge design, so that he becomes capable of tackling a new job from first principles, and is not flummoxed because the new design is not in the text-books.

Let me repeat that the Cambridge University Engineering School sets out to give a thorough theoretical engineering education, leaving practical experience to be gained in the factory. And that school, though modern, is one worthy of the great traditions of the more classical subjects that are associated with the older universities.—Yours, etc.,

J. M. KIRKBY, M.A. (Cantab.),
Assistant Foundry Manager.
The British Thomson-Houston Company, Limited,
Rugby.

December, 29, 1928.

[We are glad to publish Mr. Kirkby's letter. The note was not intended in any sense to be derogatory to Cambridge, but to welcome any developments which would advance the cause of applied science there.]

Graphite in Grey Iron Castings.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—I have just read a letter from the pen of Mr. H. J. Young in your issue of December 27, 1928, wherein Mr. Young suggests that the British Cast Iron Research Association should conduct a research with the view of proving whether or not "graphite and the size of graphite in the cupola charge affects the graphite of the iron tapped."

The suggested method is that fifty tons of 1.75 per cent. silicon pig-iron should be poured in such a manner that twenty-five tons are chilled in order to procure a white fracture and the other twenty-five tons cast so that the pigs are very graphitic. These irons should then be melted separately under standard conditions, etc. Mr. Young proceeds to state that some highly interesting information would be obtained.

If Mr. Young means by this statement that the inherent character of graphite problem would be solved, I venture to take issue with him. In fact I would go further and assert that the experiment would yield no results as far as the graphite question is concerned. The obscurity due to variables which Mr. Young so wisely denounces would, unfortunately, be very much present in the results of such an experiment.

It is, or should be, well known that white-iron when melted in a cupola passes through a stage in which it assumes a pasty condition, in which state it is extremely susceptible to oxidation, with the result that the melting is slow and the silicon percentage of the charge is decreased abnormally. For instance, from my own experience I would expect the silicon content of the white-iron melt to be about 1.40 per cent. or less. On the other hand the grey-iron melt would have a silicon content of about 1.60 per cent., and the melting would be appreciably faster. Further, I would expect more sulphur to be absorbed by the white-iron. The oxidised white-iron melt would be sluggish in pouring as compared with the grey-iron melt, such sluggishness not being due so much to the lower silicon and higher sulphur as to the condition of the iron. No doubt the tendency of white-iron to yield white-iron, even when mixed with sufficient grey-iron to give the silicon content that should produce graphitic grey-iron, is partly responsible for the inherent theory. It is, however, due entirely to the physical state and the resulting chemical reactions that occur in the cupola. For this reason, the air-furnace is the right place for white-iron as proved by the successful manufacture of black-heart malleable when using such furnaces for melting as compared to the difficulties experienced with cupola melting, although in latter years some of these difficulties have been overcome owing to the understanding gained by experience.

I think that if Mr. Young's suggestion were modified so that two heats of the same pig-iron were obtained, one of which was poured into one-inch thick slabs and the other into six-inch thick slabs, sufficient difference of character and quantity of the graphite would be obtained to give some indication of the problem under discussion upon subsequent separate melting and casting under standard conditions. Then, again, one of those prolific variables is creeping into the experiment in the dimensions of the pigs, and in order to eliminate this factor it will be necessary to cut the thick-pigs to the thin-pig size, or cement the latter securely together in order to conform to the larger size. This precaution would also have to be made with Mr. Young's suggested experiment, which meant that the oxidisable character of the white-iron would have been further favoured by the thinner pigs.

No, I am afraid the foundry is full of variables and seldom yields a plain proposition.—Yours, etc.,

W. E. DENNISON.

544, Beverley Road, Hull.
January 12, 1929.

British-Made Refrigerators.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—In the issue of your valuable publication of January 5, under the heading of "More Work for Derby," a statement is made in the fourth paragraph to the effect that the refrigerator which is to be manufactured by Messrs. Haslam and Newton, Ltd., will be the only domestic refrigerator made in this country, and I wish to point out that my company has been manufacturing refrigerators at its works in Luton, Bedfordshire, for the last three years, in which connection it is at present employing over 600 hands.—Yours, etc.,

ELECTROLUX, LIMITED,
E. D. A. HERBERT,
Managing Director.

ELECTROLUX, LIMITED,
155, Regent Street, London, W.1.

January 8, 1929.

Influence of Nickel-Chromium on Cast-Iron.

Dr. Everest, one of the authors of this Paper, which appeared on page 9 of our issue of January 3, points out, with reference to Fig. 14, that the black spots appearing in the half-inch section of the last casting shown in the diagram were faults due to defective printing and are no indication of chill in the casting.

Random Shots.

In view of the more or less perennial interest that industrial folk now take in the topic of rationalisation, I was interested to see that a leading London daily has offered a prize for "a shorter or more euphonious word. . . ." These attempts to invent words are rarely successful—in England, at any rate. Most of us always think of a man by the name he bore when we first met or heard of him, even if he comes into a title or changes his name by deed-poll. And in the same way most of us prefer the original word, however clumsy, to any later manufacture.

* * *

I remember one such contest that endeavoured to find a substitute for the word "matron," which, I believe, is considered by our not-too-old-at-forty lady friends to savour too much of the days when fireside domesticity was the only pursuit open to married women. The winning effort, I think, was "madrona," a word which seemed to me to be merely a clumsy form of the original besides being in itself ugly and un-English. Let us hope at least for something better in the present instance.

* * *

Personally, I should not like the job. No two people would define Rationalisation alike, and therefore it is unlikely that any substitute would meet with universal approval. The one merit of this admittedly clumsy word is its omnibus nature—it can cover anything and everything, according to the user's fancy.

* * *

Foundrymen are popularly supposed to find it necessary to relieve their feelings explosively now and again when things go wrong, and one or two stories about swearing, told by Mr. Robert Graves, may provide some further vocabulary to increase the number of the few overworked and practicable swear words available.

* * *

A certain general was once inspecting the famous "Z" battery of the Royal Horse Artillery, and was dissatisfied with its response to his order "Dismount!" He bellowed out: "Now *climb back again*, you pack of consumptive little Maltese monkeys!" "Z" battery complained to headquarters of this affront, and the general was in due course asked for his explanation and apology.

* * *

He gave it briefly, as follows: "Sir, I have the honour to report that, on the occasion to which I am referred, my order to dismount was obeyed is so slovenly a fashion that for the moment I was deceived. I concluded that I was actually assisting at a performance by a troupe of little Maltese monkeys, amusing enough, but crippled by disease. I tender my apologies to all ranks of 'Z' Battery for my mistake. I have the honour to be, Sir, your obedient servant."

* * *

A sequel to this inspection is also told. The general had been privately given to understand that another instance of abusive or foul language on parade would cause him to lose his command.

* * *

The day came when he was not inspecting, but being inspected, by the Commander-in-Chief of the Forces. His brigade had assembled on the field of parade half an hour before the Commander-in-Chief was expected, and the general had posted a trumpeter at the gate where the beflagged motor was expected to pull up. The lad had been ordered to sound the call for "Steady!" as soon as he saw the car approaching, but, even if it did not arrive sooner, the call was in any case to be given three minutes before the hour. He was to watch the church clock. Time passed, no car came, the call did not sound. Then the hour chimed. Infuriated by this, the general set spurs to his charger and thundered down to the gate. Passion choked him, his face grew crimson. He reined up by the terrified trumpeter, and, pointing down at him with his finger, spoke in ogreish tones: "Oh, you naughty, naughty, naughty little trumpeter!" And at that moment, under cover of a hedge, for they had left their motor-cars on the high road, up came the Commander-in-Chief and his staff on foot.

MARKSMAN.

Protecting Patterns and Core Boxes.

By J. McLACHLAN.

Patterns are expensive, yet in any shop where high-class work is turned out the life of the average pattern or core-box is much shorter than it ought to be, simply because proper precautions are not taken to protect them as far as is possible against the hard use of the foundry and the often unsatisfactory conditions of the pattern store. Where the work is of a one-off character, such as patterns for marine engineering, their protection against what may be termed atmospheric changes and mis-handling is not of as much importance as in the case of standard and repetition work, although it is a fact that better patterns, from a moulder's point of view, are often made for one-off jobs.

Painting and varnishing patterns may not always be necessary, but it is nearly advisable. At one time it was the general practice for patternshops to make red and black paint themselves. The red paint was made with red lead, terebine, turpentine and linseed oil, and the black paint often with just lamp black and spirit varnish. To-day many—perhaps most—patternshops buy paint ready for use. Very few shops make a practice of repainting even standard patterns at intervals, and yet this would have the effect not only of preserving them, but of retaining their accuracy.

Even when glue is used in the construction of patterns they are not always painted, although glued joints open when the pattern is placed in damp sand. It is rather difficult to understand why the painting of sweeping boards or strickles is so seldom done. A high-grade pattern may be made while the cores are made partly with boxes and partly with strickles. Even when the core-boxes are painted and varnished, it is not always customary to coat the strickles, although their continued accuracy is equally as important as that of either pattern or core-boxes. Skeleton patterns are not invariably painted, nor is it necessary when only one or two castings are required, although if skeleton pipe or valve patterns are of a semi-standard character, and may be wanted at intervals over a long period, they should certainly be well coated, and it should be remembered that such patterns, because they have actually to be completed in the foundry with sand, are more liable to warp and become inaccurate than solid patterns.

In very few shops is the practice adopted of fitting metal strips on the joints of core-boxes and patterns. Sometimes when standard patterns are becoming badly worn, aluminium facings are fitted on the joints of ¼ in. or ⅜ in. thick, after a corresponding thickness of timber has been planed off. This has the effect of restoring patterns, but it is rather surprising that it is not done when the pattern is new and before it has been sent to the foundry. It would often be profitable, instead of making aluminium or other metal patterns, simply to fit metal facings on a well-made wood pattern. These strips are generally made in the form of castings, carefully dowelled, and finished finally after being screwed to the pattern faces.

An alternative to metal joint plates and facings is the use of hard wood. When patterns are made of yellow pine—and, of course, the majority of patterns are made of this soft, easily worked timber—it is often possible to strengthen them and make them more durable by using mahogany or even beech for facings. We have seen many large valves used for hundreds of castings, with an almost interminable life, simply because of the use of hard wood for washers, faces of bosses, and all other parts likely to get badly worn in the mould.

The most common method of protecting core-boxes is by the use of battens. Even when boxes can be constructed of one width of timber it is wise to fit battens to counteract the warping tendency. The thickness of battens depends on their length and width, but in most cases they need not be more than 1 in. thick, and screws should always be used to fasten them. We have seen wire nails used when building large frame core-boxes, but battens cannot be expected to hold the sides or ends of a core-box against warping unless they are properly screwed. Battens used for frame core-boxes ought to be of the exact width of the core-box because they then provide a test as to whether or not the box is maintaining the correct dimensions, or is swelling or shrinking. In the case of thin metal especially battens may form an invaluable guide to the core-maker and prove whether or no the core is the exact size required.

It is not always possible to use battens when making patterns unless they are inset. When a batten is made from one piece of solid timber it can often be strengthened very considerably by fitting battens across the width of the timber into a prepared recess. A novel form of batten, of value in the case of very small patterns, is a well-fitting hard-wood dowel across the grain, and so placed that it will interfere as little as possible with any carving that is necessary.

Cadmium and its Uses.

Before the Junior Institution of Engineers recently a Paper, entitled "A General Survey on Cadmium," was read by MR. C. F. MOORE, in the course of which he reviewed the history and uses of the metal, pointing out that cadmium was comparatively little known to the general public, or even, for that matter, to practical metallurgists. It was the rarest of all the common metals and had only been produced as metallic cadmium for just over half a century. The properties of cadmium had been known for many years, but still the metal awaited extensive application in industry. By far the greater amount of cadmium had in the past been obtained from zinc ores. Cadmium had more nearly the colour of steel than of tin and had a brilliant lustre when freshly cut or polished.

Cadmium (continued the author) is a soft metal; it will mark paper and can be cut with a knife. It is harder than tin, and softer than zinc, standing between tin and gold. It is malleable and ductile at ordinary temperatures and can be rolled into sheets and drawn into wire.

The most important sources of cadmium are cadmiferous zinc ore, sulphide, silicate or carbonate, which are found in Upper Silesia, Australia, United States, Spain, Sweden, South America, Great Britain. The sources from which cadmium is obtained are as follow:—

From Zinc Ore.—(1) Flue dust of blende-roasting furnaces; (2) condensed fume, blue powder or zinc dust formed in the distillation of zinc ores; (3) condensed flue fume from brass-melting furnaces; (4) products from the extraction of zinc by electrolysis; (5) vat residues remaining precipitated from zinc liquors in the manufacture of lithophone.

From Lead Ore.—(1) Condensed fume from lead blast furnaces; (2) vat residue from electrolytic-lead refining.

From Copper Ore.—Condensed fume from copper blast furnace.

The principal material in Europe is zinc dust formed in the distillation of zinc ores, whilst the principal American output is derived from condensed fumes from lead blast furnaces.

The specific gravity of cast cadmium is 8.6040; hammering increases this figure to 8.6944. The tensile strength is such that it breaks under a gradually-increasing stress with the characteristic fibrous structure of a soft, tough metal having a tensile strength of about 6 tons per sq. in., the elongation being 44 per cent. on a 3-in. gauge length. Its tensile strength lies between that of zinc and gold. Its malleability and ductility are such that it can be beaten out into thin foil and drawn into fine wire.

The chemical behaviour of cadmium is in most respects similar to that of zinc and is soluble in dilute acids, dilute nitric acid being by far the best solvent for the metal. The most commercially important compounds are the chloride, the sulphide, sulphate, carbonate, oxide, hydrate, and the cyanide, but most particularly, the sulphide. The vapour of the metal, as well as the soluble salts, are highly poisonous. The salts have antiseptic properties.

Cadmium Alloys.

There are comparatively few of the commoner elements with which cadmium has not been alloyed, and in many cases most of the properties of these have been scientifically studied. The growing interest in cadmium and its alloys has of late stimulated investigation along practical lines, and already new properties and uses are rapidly being discovered. A few cadmium alloys are as follow:—Copper-cadmium, containing about 1 per cent. of cadmium, is used for the trolley wire on tramway systems, tests having shown that it increases the life twice to three times that of the best hard-drawn copper wire used for telephonic, telegraphic and power transmission purposes. One per cent. of cadmium in the wire raises the tensile strength from between 26 and 27 tons to about 51 tons per sq. in., and the conductivity is maintained at about 91 per cent. In aluminium foundry practice it is customary, where unfinished castings are required, to add anything from 0.5 to 5 per cent. of cadmium to the bath of fused aluminium. As a deoxidiser it is also added as a deoxidant to molten nickel before casting. It is also added to silver solder.

Numerous alloys for bearings, containing cadmium, have been patented, for which are claimed a very low coefficient of friction.

Exhibition and Convention of the American Foundrymen's Association.

The exhibition and convention of the American Foundrymen's Association will be held from April 8 to 11 this year at the Hotel Stevens, Chicago. A diversified programme has been arranged, and several features of unusual interest will be included. A series of Shop Operation courses, dealing with the fundamentals of shop practice, will be given, and several prominent speakers will discuss matters of great importance to foundrymen. These will include such subjects as Foreman and Apprentice Training, Non-Ferrous Foundry Costs, Sand Control, and Metallurgy and Shop Practice.

Belgian Foundrymen's Association Reorganised.

The Belgian Foundrymen's Association, at the last meeting, was reconstituted. An entirely new set of rules was adopted, and a new executive council formed. Mr. Marcel Rémy, of Herstal-by-Liége, was elected President, and Messrs. Paul Ropsy (the Past-President), Rabozée, Palyn and Werz as Vice-Presidents of the Antwerp, Brussels, Flanders and Hainault sections respectively. Mr. Deprey is Secretary, and Mr. Piedbœuf, the Treasurer. The following gentlemen, Messrs. Preyard, Léonard, Varlet, Carlier, Falleur, Lamoureux, and Foulon, were elected members of the Council.

The next meeting will be held at Brussels this month.

Wages in Scottish Malleable Iron Industry.

A deadlock has arisen between the Scottish manufactured iron trade employers and the Iron and Steel Trades Confederation regarding the wages and hours of men employed in the malleable iron industry. The employers wish to introduce a five-day week of 47½ hours and to reduce the rate of wages, which, they state, would enable the men to earn as much as they do at present with a 40-hours week. Parties failed to agree, and the union offered to submit the matter to arbitration. The employers replied that they would accept arbitration as far as wages were concerned provided the men accepted the hours proposals. A deadlock ensued, and the employers have now given notice that they will terminate the conciliation and arbitration board, with a view to making arrangements with the men at the iron works. Notices are being posted to take effect in fourteen days. About 2,000 men will be affected.

Chromium Plating for Resisting Wear.

At the annual meeting of the American Society of Mechanical Engineers, held in New York on December 3-7, a Paper on "Chromium Plating in Wider Use for Resistance to Wear," was read by MR. W. BLUM, in the course of which he stated that simultaneously with the extensive use of chromium plating for the finish on exposed metal, its application for "wear resistance" had received careful consideration in many and varied industries.

So far as known, no data were recorded upon the tensile strength and ductility of electrolytic chromium; probably because of the great difficulty of preparing suitable test specimens. Qualitative tests showed that its ductility was almost zero. This fact largely accounted for the tendency of relatively thick chromium deposits to chip or flake under impact. The adherence of chromium to the underlying surface when heated, either directly, as in a glass mould, or indirectly, as on a cutting-tool forming die, depended partly upon its coefficient of expansion, or more strictly upon the relation between the coefficients of chromium and of the base metal. The available data on the coefficient of electrolytic chromium probably were not of high accuracy, on account of the difficulty of preparing long, coherent specimens. The linear expansion coefficient given in International Critical tables for the range from 0 to 500 deg. C. is 8.1 by 10^{-6}. This value is similar to those for glass and platinum, and much less than those for iron, copper, nickel, zinc and most of the common alloys. This fact undoubtedly accounted for part of the difficulty experienced with flaking of chromium from articles subjected to high temperatures in service. It also suggested the possibility that for special uses, alloys with an expansion coefficient closer to that of chromium might be employed.

Durability of Chromium Plating

The high melting point, 1,615 deg. C., of chromium made it unlikely that the plated coating will actually fuse under any conditions to which it was put in mechanical equipment.

Occasional failure of electro-plated chromium to adhere to the base metal under severe conditions of service was one of its serious limitations. The adherence no doubt depended upon (1) the conditions of deposition, which determine the structure, hydrogen content and ductility of the deposit; (2) the composition of the base metal; (3) the method of cleaning or preparing the base metal; and (4) the conditions of service, including the temperature, and the nature and magnitude of the strain imposed upon the coating.

In general, it was not so difficult to obtain satisfactory adherence of the chromium to a plain carbon steel, even when case hardened, as it was to certain of the alloy steels that are used for tools and dies. Observations indicated also that it was more difficult and required a higher current density to produce satisfactory deposits on steels containing chromium and tungsten than on other steels.

It had been observed frequently that many liquids, including water and even molten metals, did not readily wet a chromium surface. This behaviour, which might be due to surface films, materially increases the tarnish resistance and protective value of the chromium coating. The value of chromium upon bearing surfaces might depend not only upon its coefficient of friction under given conditions, but also upon its ability to resist abrasion and chemical action, and thus to maintain for a longer period the initial condition of the surface. Chromium plating had proved especially valuable on measuring devices, because its resistance to abrasion decreases the tendency for any change in dimension, or for any obliteration of graduation marks. The latter factor justified its use on linear scales, verniers, micrometers and tapes.

Continuing, the author said that chromium had been more extensively and more successfully applied upon plug gauges than on any other measuring devices. The life of the plated gauges in service was estimated to be from three to ten times that of the unplated gauges. Although it was possible with proper control of the plating process to deposit upon a gauge exactly the requisite thickness of chromium and to use the gauge without subsequent lapping, experience had led in almost every case to the deposition of a somewhat thicker coating, the excess of which was then ground or lapped off. In general the chromium coating should be thick enough so that it will not be penetrated when the gauge was worn down to its lower wear limit. It was then a simple matter to strip off the chromium by a reverse current in a sodium-hydroxide solution and to replate to the desired dimension.

Application to Thread Gauges.

Although chromium-plated thread gauges were used now in several plants, much uncertainty and scepticism exists regarding their reliability. This doubt arose from the difficulty of depositing chromium uniformly upon the surface of the threads. In any plating process the deposit was always thinner in a depression than upon a projection, and this difference was accentuated by the poor "throwing power" of the chromium-plating bath. As a result of the uneven distribution of chromium upon the threads, not only the diameter of the gauge but also the thread angle was altered. It was, therefore, usually necessary to regrind the gauges after plating, unless they had been previously so ground as to allow for the uneven distribution of the chromium. It might be stated safely that chromium plating will prove valuable upon any measuring device which is subject to abrasive wear in service, provided the shape was such that the chromium could be applied with reasonable uniformity.

Chromium plating of dies and mandrels used for tube drawing was reported generally as satisfactory while on wire-drawing the process was usually unsatisfactory. The latter were reported as failing through flaking or peeling of the chromium, and subsequent scratching of the wires. The only obvious explanation of this discrepancy was that the apertures in the wire dies were usually much smaller, and, therefore, more difficult to plate uniformly than those in the tube dies. This tentative explanation was supported by the fact that the tube-drawing dies, even when successfully used, were less satisfactory than the mandrels. In connection with the manufacture of hot-rolled seamless steel tubes, the successful use of chromium-plated drift balls was reported. This application no doubt rested partly upon the resistance of the chromium to oxidation at the elevated temperatures employed, as well as upon its resistance to abrasion.

Favourable reports were received regarding the value of chromium plating upon dies used for forming sheet steel and brass. In some cases the life of the dies was increased up to eight times the normal service. One special advantage observed with the chromium-plated surface was that the metal does not stick to it as much as to steel. It was significant that the thickness of the chromium coating on these dies was less than 0.0005-in.

Chromium-Plated Steel Rolls and Tools.

In some cases chromium-plated rolls used for crushing softer materials such as cereals had proved much superior to hardened steel. Data received regarding chromium on tools used for cutting metals were more variable and less favourable than those for any other uses. The most consistent gains are obtained when cutting such substances as slate, asbestos board, and bakelite, which materials, though commonly referred to as "soft," cause rapid wear of steel tools.

Chromium-Plated Saw Blades.

Chromium-plated saw blades gave varying results. The experience with plating on saws of various types is like that with other cutting tools. If a thick coating is applied there is a marked tendency for the formation of nodules or "trees" upon the points of the teeth. These dull the points, and if, as usually occurs, they break off in service they leave the teeth rough and irregular. For such articles it is therefore preferable to use thin coatings.

A few reports upon woodworking tools, including saws, chisels, and lathe tools, showed that their life was greatly increased by the use of chromium coatings. Experiments are being made also by one firm upon chromium-plated ploughshares. In a few cases chromium-plated gears had proved satisfactory. ("Iron Trade Review.")

The British Steel Foundry and its Position To-day.

BY G. E. WELLS.

The iron and steel industries in this country are passing through very difficult times, and many are beginning to wonder whether or not solutions of the problems confronting these industries will ever be found.

The steel foundries are faced with the same set of circumstances as those which the steel industry in general has to tackle, and those actively engaged in the manufacture of steel castings who have examined the situation from every angle are compelled to admit that the way to a successful solution of their difficulties is by no means clear. The problem resolves itself into two main headings:—(1) Foreign competition; and (2) the immense excess of production capacity in this country over demand.

The former difficulty may or may not be solved by the imposition of import duties on foreign material. On the other hand, it must be recognised that much of the foreign competition which the English founder is endeavouring to fight against is grossly unfair, if only for the reason that the standard of life of the steel-foundry workmen in foreign countries is very much lower than that which British workers have every right to expect.

The writer has had occasion to spend much time abroad during pre-war and post-war years, and has no hesitation in stating that a continental foundry competing with the Edgar Allen plant has the scales heavily weighted in its favour. Apart from the wages advantage, there would seem to be no doubt that a great deal of the material purchased by English and Overseas engineers from continental steel foundries is by no means up to specification, whereas in this country inspection is so rigid that a buyer may be perfectly certain of getting material well within the limits of his specified requirements.

In regard to foundry capacity in the British Isles, it is well known that large extensions were undertaken during the war for national reasons, and even since the war certain firms have substantially increased the size of their plant. The situation to-day is entirely in favour of the buyer who can play off, one against the other, a number of firms all hungering for orders and willing to take them even at a loss in order to find employment for their workpeople and to prevent the closing down of their foundries. The result is that, with very few exceptions, steel foundries to-day are definitely working at a loss, and it would seem that ultimately the only effective solution will be the "survival of the fittest."

This process is seen in operation amongst the collieries, certain pits having been forced to close for economic reasons and the owners of the others having got their heads together to limit production and consequently force up prices. The increases for raw materials now being demanded will inevitably increase the difficulties of the steel founder, and if the doctrine of the "survival of the fittest" is a sound one, these increases will tend to speed up the process of elimination, and so to reduce the foundry capacity of the country nearer to the total demand. When this takes place, there is no reason to think that prices of steel castings will substantially increase, as it is obvious that if the more efficient foundries could procure more work, the incidence of their overhead charges would be considerably reduced, and the only increases which they could justify would be those due to advances in prices of raw materials or to higher wages.

* Extracted from the "Edgar Allen News." The author is director of and foundry manager to the firm which publishes this house organ.

Alloy Cast Irons.*

By Arthur B. Everest, Ph.D.

Introduction.

No apology is needed for bringing to the notice of foundrymen any development which concerns the processes and materials which form the basis of their trade. In fact, to-day, with the more rigorous demands on the properties of materials, which are the natural results of engineering progress, it is clearly the duty of the producers of castings to do their part towards improving their products so that these can meet the more rigorous demands made of them. At the present time, unfortunately, the foundry industry is reaping the fruits of the neglect until comparatively recently of any organised development, and engineers for the most part have been inclined to regard cast iron as a material which will be cast into a shape, and as long as it will keep that shape and possess a small amount of strength, then it is considered satisfactory. The same engineers, when they require a better quality material, are showing a tendency to-day to turn to steel or other alloy at a greatly increased cost in order to replace cast iron which they find is now inadequate for their needs. Cast iron definitely has better casting properties than has steel, as some who have from time to time endeavoured to replace the former by steel have learnt to their cost. Development on the field of cast iron has been hampered by the lack of funds available for research and experiments in the foundry; but to-day active bodies whose endeavour it is to introduce to industry the latest developments as they come to hand, are assisting individual firms through the experimental stages whilst such developments are being initiated.

Amongst the developments of to-day in the cast-iron world, alloy cast iron is receiving considerable attention, and the author has been privileged to have been associated with this work during the past five years. In numerous papers, the results of experimental work have been set out, and these have in most cases been enhanced by confirmatory experiments carried out under working conditions. In the near future it is hoped to have many more practical results in the field of alloy cast iron available for general consideration. In the meantime, however, whilst various large firms are actively engaged in developing these new materials on a production basis, it is felt that it might be worth while to give some general consideration to the reason for making alloy additions, and to the results which, from the general knowledge of cast iron, might be expected to accrue.

In order to obtain the best results in any modern development it is necessary to have some understanding, not only of the particular conditions associated with the development, but also of the general structure and behaviour of the material which is being handled. In a recent article published in THE FOUNDRY TRADE JOURNAL [1] the author put forward a general working theory of cast iron and showed how the common-sense views held to-day by all who handled this material could be directly related to the more advanced theories, as for example, that recently evolved by Professor Hanson.[2] It is interesting to note that support of the author's views concerning the formation of graphite at high temperatures has recently come from Germany.[10]

A General Theory of Cast Iron.

As the author's views on alloy cast irons are based on his general theory, it will be necessary briefly to recapitulate his ideas in this connection. In the above-mentioned article he stated that the ultimate structure of a cast iron is determined primarily by only two factors. These factors are shown to be (1) the relative stability of the carbide and the graphite in the iron, and (2) the thermal history of the sample of iron under consideration. It was pointed out that heading No. 1 corresponds to the statement that the character of the iron in the given casting is determined by its composition. For general consideration cast iron may usefully be divided into three grades. The piece of iron examined may have a white fracture, when the iron is hard and unmachinable, and the carbon is present principally in the carbide form, in which case, in the author's view, carbide may be stated to be relatively more stable than graphite. The iron in the casting may, on the other hand, be grey, in which case the iron is machinable, the hard carbide constituents in the white iron mentioned above now being replaced by soft graphite. Grey cast iron may be further subdivided into hard or soft grey iron. In the former a residuum of combined carbon gives the matrix of the iron a pearlitic structure. This class of iron corresponds to what would generally be called a high-quality engineering iron. If the composition of the iron, however, is such that nearly all the combined carbon has been broken down to the graphitic form, then the iron will have a soft matrix, giving the third form of cast iron—a soft grey material. By experience it is known that in a given section, by modification of the composition, these different structures can be obtained. Thus, for example, in a low-silicon iron containing chromium, relatively heavy sections of the casting may be white.[2] The same section, however, cast in a plain normal silicon iron would be of engineering quality, possessing a strong, hard matrix. And again, if the same section be cast in a high-silicon, high-carbon iron, a soft grey structure will be obtained. Thus modification of the composition results in definite changes of structure and properties in the cast iron.

Factor 2 in the above general statement indicates that the structure of the iron is determined by the thermal history of the sample under consideration. This clearly covers the rate of cooling of the iron from the molten state, as well as any subsequent heat treatment of the casting; thus an automobile cylinder iron, for example, cast into a $\frac{1}{16}$-in. section would generally show a white fracture, whilst the same, cast into a $\frac{1}{4}$-in. section, would give a grey iron with a pearlitic matrix. If this latter section now be annealed at 700 deg. C. for two or three hours it will be found that the pearlite matrix will be decomposed and all the carbon broken down to the graphitic form. This general theory has been fully elaborated in the author's previous article, to which reference should be made for further details.

Influence of Composition.

A consideration of the above general remarks indicates that modification of the composition will produce a direct effect on the structure of cast irons by altering the relative stability of the carbide and the graphitic forms of the carbon present, and in general increased proportions of normal or special elements in the irons tend to change this stability in one direction or the other. It must be emphasised that in this general statement, relatively small alloy additions only are being considered; the remarks clearly do not hold if, by the addition of the alloy element, a new phase is introduced, as would be the case on making larger additions of certain elements. Thus it is found that the elements which definitely alloy with cast iron can be divided into two groups. The first covers those elements which, in general, are regarded as softeners in cast iron, that is, that they favour graphite formation; the second group covers those elements which harden the irons by increasing the amount of combined carbon. The first group contains such elements as silicon, nickel and aluminium, whilst in the second there are such elements as sulphur and chromium, and, under certain circumstances, manganese and phosphorus.

If an added element will alloy with cast iron, that is to say, it is miscible with the molten metal and is held in solution in some form or other in the solidified cast iron, then usually it can be assigned to one or other of the two above classes.

In addition to the action of an alloy element on carbide or graphite development, definite modification of the various micro-constituents of the iron will take place with resultant change in the properties of the metal as a whole. The structure of cast iron is very heterogeneous and the properties of castings are determined by the properties of the various components of this structure, as well as by their relative coarseness, distribution and such like. Generally speaking, however, primarily only two of these components need be considered; these are the graphite and the matrix of the iron. In a recent discussion[3] it was definitely suggested that the coarseness of the graphite form was the determining influence on the strength properties of any particular casting; this, however, is a matter of opinion, and the author believes that in this review the graphite form cannot be separated from the condition of the matrix in an ordinary iron, the two being controlled by the same influences. Alloy elements have their influence not only on the development of graphite but also on the form in which the precipitated graphite occurs. This is a very important point, as it enables one to obtain improvement in strength figures in a cast iron of certain carbon content, through the control of the coarseness of the precipitated graphite produced under given conditions.

As mentioned before, in the class of iron the author has under consideration, the matrix is generally pearlitic. Once again the presence of alloy elements has a very profound influence on the nature of the pearlite occurring under given conditions. Thus, in the presence of silicon, pearlite is often coarsely lamellar, but under corresponding conditions in the presence of an equivalent amount of nickel the pearlite is generally very fine, and may even be sorbitic. It is thus evident that even if one retains the relative proportions of free and combined carbon in an iron of given total carbon content, great modification of the inherent properties of the iron may be obtained by suitably controlling the disposition of these forms of carbon through the medium of alloy elements.

Some of the various elements normally occurring in the iron produce other phases or constituents in the structure; as, for example, the phosphide eutectic, which results from the presence of phosphorus in irons, especially of high combined carbon content; and also manganese sulphide, which usually occurs to a small extent in all cast irons.

In the author's experience little modification of these other phases is brought about by the presence of small quantities of alloy elements; and, as mentioned in previous publications, the weakening effect in an iron by the presence of excessive phosphide cannot be mitigated by the use of alloy elements. There is no suggestion made that high phosphorus iron may not be improved by the use of alloy elements, but it is the author's opinion at the present time that better results for high duty purposes, both in normal and alloy irons, are obtainable by the use of a low phosphorus base.

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* Paper read before the Institute of British Foundrymen (London Section) on January 10, 1929.

In considering then the influence of a special element in cast irons, it is necessary to take into consideration first its effect on the production of carbide or graphite, and secondly, its effect on the various micro-constituents which either existed previously in the iron or are produced through the agency of the element, and, moreover, the effect of these modifications of structure on the properties of the casting as a whole must be evaluated and balanced against the actual economic cost of the alloy additions. Clearly it is not worth while making an expensive addition to cast iron if only a minor modification of properties results from it. If, on the other hand, by means of a reasonable-priced addition, appreciable benefit in the irons can be produced, then a definite claim is made on behalf of this alloy element.

In evaluating the actual cost of making any addition not only must the actual cash value of the added element be considered, but also the possible modification of the initial metal charge, and also the economic aspect of the influence of the added element on production as a whole, and the possible reduction of the number of scrap and waste castings inevitably produced in the foundry.

The Choice of Alloy Element.

Bearing in mind the above general points which must govern the choice of a suitable element for adding to cast irons, the number of possible alloy additions is at once strictly limited. Perhaps the first consideration can be stated to be that the element must be easily added to the cast iron without running any risk of explosion or of excessive oxidation, this clearly ruling out such metals as the low melting point alkalis; the added metal as mentioned above must also alloy with the cast iron. This again limits the field by cutting out such metals as lead.

The question of cost will again limit the field; for clearly one cannot afford to make a very expensive addition to a material of the class of cast iron, except perhaps for some very special service, in which case the cost of the special element will be refunded. Thus ultimately only a comparatively small number of elements is to be considered. Preliminary work on the influence on these elements has, in many cases, already been carried out; but up to the present little further progress has been made in the development of special cast irons containing these elements.

Among the elements which have already received such attention we find aluminium, chromium, cobalt, copper, magnesium, manganese, molybdenum, nickel, silicon, sulphur and titanium, and besides these some of the rare earths and precious metals which it seems unlikely could ever find economic application in cast iron.

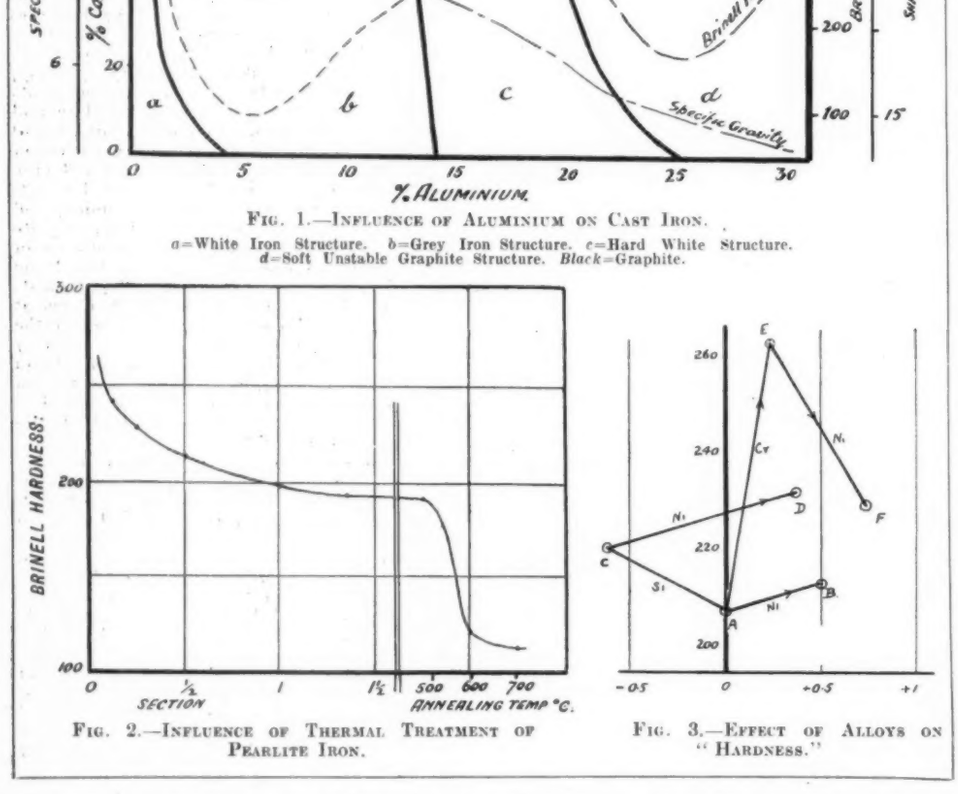

FIG. 1.—INFLUENCE OF ALUMINIUM ON CAST IRON.

a=White Iron Structure. *b*=Grey Iron Structure. *c*=Hard White Structure. *d*=Soft Unstable Graphite Structure. *Black*=Graphite.

FIG. 2.—INFLUENCE OF THERMAL TREATMENT OF PEARLITE IRON.

FIG. 3.—EFFECT OF ALLOYS ON "HARDNESS."

Influence of Aluminium.

In considering the development of special cast irons the author first turned his attention to the influence of aluminium. It was felt that cast iron, alloyed with this element, might perhaps possess valuable properties with regard to resistance to heat and corrosion. Experiments accordingly were initiated in which various amounts of aluminium were added to cast iron. It has been mentioned above that aluminium is found in the group of elements which soften cast iron by decomposing carbides. This fact was adequately established by the production of grey cast iron containing no silicon, but with a small content of aluminium.

The result of the author's investigations broadly confirmed the results of previous workers, though much of this earlier work was performed before the year 1900. It is not considered necessary to deal with these results in great detail as a fuller statement is given elsewhere.[6] It was shown that small additions of aluminium to a silicon free iron-carbon alloy, produced continuous graphitisation until about 7 per cent. of the added element was present. From this quantity up to about 15 per cent. of aluminium, carbon was taken back into the combined form, giving a hard, brittle material. With a further addition of aluminium, graphitisation occurred again with re-softening of the metal; and some very curious test-pieces were obtained which showed non-magnetic, anti-corrosive and non-oxidation properties, but the alloys were either unmachinable, or proved very unstable; in some cases graphitisation of the iron poured into a chill mould being so violent as to eject molten iron from the mould, whilst pockets full of graphite were found in the resulting castings. Pieces of this material also showed a tendency to decompose and disintegrate when left standing in a moist atmosphere.

The diagram, Fig. 1, gives a summary of these results obtained in the series made up by adding aluminium to a pure iron-carbon alloy. The body of the diagram gives the microstructures obtained in ¼-in. sq. bars, cast in sand, with the various aluminium contents indicated. The regions in which free graphite is produced, and also where the original white iron structure is eliminated, are clearly shown. It will be obvious that it is impossible in a diagram of this type to indicate accurately all the structural changes which are taking place in the iron; thus, for example, it must be realised that in region *b*, corresponding to the formation of pearlite, the actual form and structure of the pearlite progressively change as the aluminium content is increased. This has been elaborated sufficiently in the original publication to which reference has been made.

This diagram is of great interest in showing the connection between the microstructure and properties of a material; the very powerful influence of the hard white phase *c* (which probably contains aluminium and iron carbides, either separately or combined) is indicated by the inflection shown in all the curves. This is very marked in the hardness curve, which has a form, as would be expected, roughly following the combined carbon content of the alloy. The inflection in the specific gravity curve is also very clearly marked, and it will be noticed that in all the curves shown the inflection corresponds almost exactly with the occurrence of this hard phase *c*.

The author is concerned, however, as stated above, primarily with small additions of alloy elements which produce modification of the normal structure of cast irons, without the development of new phases in the structure. Some practical scale tests were made with irons containing aluminium in place of silicon,[7] but in these tests no very great benefit from aluminium employed in this manner was apparent. The graphite form produced by the aluminium was not appreciably different from that produced by the corresponding amount of silicon, and although modification of the pearlite structure was seen, this has not resulted in any marked special properties in the alloy irons.

Tests were carried out also on some aluminium-chrome cast iron; but once again no very special claim for improved properties could be made for this material to justify the cost of the alloy addition and the added expense and difficulty in handling this mixture.

As a first approximation it was found that it required about two parts of aluminium to produce the same effect as one part of silicon. The result of this investigation was somewhat disappointing in that no very special properties were shown by grey cast iron containing aluminium and aluminium-chrome as compared with similar

material containing the more usual silicon. Moreover, thermal analysis indicated that the aluminium iron was not stable under heat, and the carbide structure could be completely broken down by a short annealing at 750 deg. C.

A much more serious impediment to the general employment of aluminium was found, in that aluminium in virtue of its action as deoxidiser of the molten iron itself, becomes partly oxidised when added in the ladle, and this oxide is very difficult to remove from the melt, so that ultimately unsound spots containing alumina are found in the body of the casting; moreover, the molten stream of metal showed a tendency to become coated with a leathery skin of aluminium oxide, which tended to break up and be carried into the casting, where it was ultimately found entrapped in the body of the metal, again producing serious unsoundness.

It is claimed that these oxidation effects in aluminium cast iron present a difficulty which would require further investigation for some satisfactory solution of the problem of its elimination to be evolved. The author does not wish to suggest that this problem is insurmountable, and some day aluminium cast iron may be extensively employed, but he does at the moment emphasise it as typical of the type of difficulty which might be met in employing alloy elements, and which by introducing practical complications in the foundry, with resulting tendency to the production of scrap castings, will therefore not meet with favour even though the cost of the addition be reasonable and the resulting iron possesses good properties where castings are successfully made.

Influence of Nickel on Cast Iron.

A great deal of publicity has been given abroad to the use of nickel as an alloy element in cast iron. Some British manufacturers who proceeded to investigate this development for themselves, however, in the first place obtained disappointing results through lack of appreciation of the conditions necessary for obtaining the best improvements from the use of the alloy addition. Accordingly it was considered desirable to continue the investigation of alloy cast irons by giving some attention to this subject, and it was decided initially to study the fundamental influence of nickel in cast iron with a view to finding a rational basis from which the commercial application of this material might be developed, if the results were sufficiently promising. The choice of nickel for this purpose is not very surprising in view of the fact that nickel possesses several properties which render it eminently suitable as an alloy-element if the results obtained from its use justify the expense involved. The application of nickel in steel is well known, and is indicative of the ease with which this element will alloy with the iron-carbon system. Moreover, manipulation of alloy steel has endorsed the appreciation of the fact that nickel is not readily oxidised and consequently losses of this metal in making up alloy irons, or in remelting them, are negligible. Extensive experience has shown definitely that 100 per cent. recovery of the nickel added can be expected from any furnace operation. Comparing this with the results obtained on aluminium in cast iron, it is evident that there is little likelihood of trouble from the inclusion of slag or oxide in the metal, introduced through the agency of the special alloy addition.

In the first part of the research on nickel cast irons, which has been carried out at Birmingham University under Professor D. Hanson, a very extensive investigation was made on the fundamental influence of nickel on iron-carbon and iron-carbon-silicon alloys.[3]

The results of this investigation confirm those obtained by other workers, and have produced some general principles on which the further development of irons of this class must be based. A consideration of the influence of nickel, and its application in certain commercial castings, was given by the author in the British Paper submitted to the Barcelona Congress at Easter. It may briefly be stated that as a result of the research and experiences up to the present time, nickel definitely falls into the class of elements which favour the formation of graphite in cast iron; but its action is milder than that either of silicon or aluminium.

Experiments conducted on the combined carbon content of annealed cast irons having normal composition have given results which show clearly that in a normal engineering iron—chill-cast so that it contains initially pro-eutectoid cementite—this form of carbide is relatively much less stable under heat than is the finer pearlitic cementite. The result of this is that in a silicon iron which is subject to mild annealing conditions, or retarded cooling, the carbide in excess of that required to give a pearlitic matrix may comparatively readily be broken down leaving a combined carbon content of about 0.6 to 0.8, which corresponds to the pearlitic structure found frequently in this class of iron. This structure has a hardness value of about 175 to 210 Brinell. Referring to pearlitic cast iron in his recent discourse, Mr. Shaw[4] mentioned the fact that frequently the difficulty was not to obtain a pearlitic structure in irons of the engineering class, but rather to avoid obtaining it. Further evidence which emphasises the relative stability of pearlite is given in Fig. 2, which shows a typical curve obtained for the hardness values in an ordinary cast iron. This curve is made up of two parts, which strictly speaking are not entirely comparable, but they serve to emphasise the point under consideration. The first part connects hardness with section thickness, and the second with annealing temperature, each sample being annealed at the given temperature for one hour. The stability of the pearlitic structure is emphasised, but, as shown, once conditions initiate a decomposition of the structure, the decomposition proceeds generally very rapidly to completion.

The result of the mild action of nickel as a graphitising agent is that in a hard iron graphitisation generally proceeds actively only as long as the combined carbon is in excess of that required to produce a pearlitic matrix, and, in consequence, such irons become stabilised showing a pearlitic structure over a wide range of cooling conditions. Thus in irons of varying section hard spots resulting from chill are eliminated by the use of nickel, while the hardness of the heavier sections is maintained; in fact, it may be stated that even in very large sections, a high combined carbon content has been found uniformly distributed throughout the body of the casting, where a reduction in silicon is made to counterbalance the initial graphitising effect of the nickel. This is one of the principal features on which the economic application of nickel in cast iron is based; *for the net result of the influence of nickel is to give an equalisation of the structure and hardness throughout castings of varying sections*, which would not be possible in an ordinary iron. This application has very far-reaching possibilities, for not only does the use of nickel make it possible to work a much harder metal mixture having improved wearing and strength properties without running a risk of getting castings which are unmachinable through the presence of hard carbide spots; but also it becomes increasingly apparent that many advantages result from the equalisation of structure, and common difficulties which occur daily in foundry work may be minimised.

Results are to hand which show that by the replacement of silicon in cast irons by an equivalent amount of nickel, sounder and denser castings are obtained, which in many cases show a freedom from the porosity which had been associated with the same part cast in ordinary metal. This is probably due to the elimination of unequal and excessive contraction on solidification resulting from wide variations in structure, consequent on section differences. As has been stated before, one of the principal applications of nickel depends on the fact that the use of a low silicon cast iron, with its well-known improved strength and soundness, becomes possible; since nickel will render this iron machinable without impairing the good qualities of the low silicon base.

A general all-round improvement in the properties of cast iron alloyed with nickel has been demonstrated, with the consequence that these irons are finding application for all types of castings which have to stand up to high duty requirements. These applications include especially castings in which increased mechanical strength is desired, together with improvements in such other properties as resistance to wear, corrosion and shock. No very great claim can yet be made for improved resistance to corrosion on the part of these irons containing small alloy additions, but it is mentioned above since corrosion in such equipment as hydraulic machinery is very often associated with wear and abrasion; thus the slight improvement in the actual corrosion-resisting properties of the iron on alloying is augmented by the simultaneous improvement of its resistance to the scouring and wear to which such parts are subjected.

If one considers the action of nickel and of silicon in terms of the general theory of cast iron which has been given earlier in the Paper, it is found that throughout castings of the class under consideration a definite proportion of the total carbon in each iron is required to be retained in the combined form. The tendency of nickel has been shown to be essentially that of graphitising iron above the pearlitic range, and it has a very mild effect below this range. The action of silicon as is well known is in the same sense, but is much more powerful. It is accordingly clear that to retain the maximum combined carbon in the iron, a lower silicon content should be used than is required for the same casting in ordinary iron. It is not claimed that the addition of nickel produces no benefit when added to ordinary iron, for it has adequately been demonstrated that some benefit does result from such an addition. It might be emphasised once again, however, that the best properties are to be obtained when the nickel addition is connected with a high combined carbon, and this is usually obtained by reducing the silicon content, in a proportion suitable for counterbalancing the graphitising effect of the nickel added.

Little experimental work has yet been done on irons which show a soft ferritic matrix. It is possible that some improvement of this matrix would be obtained from the use of nickel, but it need hardly be emphasised that where such a structure occurs in an ordinary casting which has not been heat-treated, the structure will be associated with a coarse graphitic form which will mask any improvement in the properties of the matrix. Accordingly, at the present time, it does not appear at first sight as though iron of this class would repay investigation. It has repeatedly been pointed out in literature on nickel cast iron that the principal benefit obtained from the use of nickel results from its action on the pearlite present, and that to obtain the best results a maximum pearlite content should be maintained.

Use of Nickel-Chromium.

The above general principles indicate that where castings are made for high duty requirements, a reduction in the normal silicon content is desirable in order to counteract the slight graphitising effect of nickel and to obtain the maximum amount of combined carbon. The usual reduction in silicon which is recommended, is of the order of about $\frac{1}{4}$ to $\frac{1}{3}$ per cent. for each per cent. of nickel. For some classes of work this reduction in silicon may not be a practical proposition, accordingly we have the development of nickel-chrome cast iron as an alternative to low-silicon nickel irons.

Influence of Chromium.

The influence of chromium in cast iron has been recently dealt with in experiments carried out at Birmingham University, and the results have been given very fully in a Paper on the subject of nickel-chromium which has just been published.[5] Very briefly, the influence of chromium is definitely to render carbide more stable than graphite. Consequently, in most cast irons the addition of chromium renders them harder and progressively increases the amount of combined carbon present, turning grey sections to white. It is thus seen that chromium acts in the opposite direction to nickel; but in hardening cast iron, small amounts of chromium also improve its mechanical properties at the same time as its tendency to chilling is increased, and this improvement is maintained during the subsequent addition of nickel. Thus, by the use of the combined nickel-chromium addition in which the components are so adjusted as to counteract each other's effect on chill,

the machinability of the casting may be retained while yet improving its general properties. This feature has been summarised very effectively in Fig. 18 of the Paper referred to, and for fuller details of the combined influence of nickel and chromium this should be consulted.

There is little to show yet whether the low-silicon nickel iron or the nickel-chromium mixture will give the better results, and the choice of which is used must clearly be determined by circumstances. For heat-resisting castings it is possible that the low-silicon nickel mixture might give the better results. Again, in a jobbing foundry, where two or three standard mixtures are in use, then it may be that nickel can very effectively be used in a harder grade of iron than is normally employed for certain castings, and this may often enable a cheaper base iron to be used. As a definite example of this the case of a foundry making automobile cylinders and also small Diesel castings may be cited, the respective silicon contents being 1.8 and 1.4 per cent. in mixtures otherwise similar. In this case a very satisfactory iron for automobile cylinders is obtained by adopting the Diesel iron for this, and adding ¾ to 1 per cent. of nickel. It will be apparent that by methods such as these, simplification of procedure in the foundry may result from the use of nickel by the elimination of some of the metal mixtures normally run. In the case of a foundry, however, in which various castings are made from one standard grade of iron, then manipulation of this one grade by the addition of both nickel and chromium may be the more economical method, and prove of greater simplicity than any modification of the normal charge: it is seen therefore that local circumstances must in general be the determining factor as to which procedure is adopted. Brief reference might be made to the fact that reduction of silicon may frequently be effected by the use of increased amounts of steel scrap in the furnace charge, and this is frequently associated with a reduction in metal costs which in part help to compensate for the expense of the alloy addition.

Cost of Alloy Additions.

The methods of making alloy additions have been dealt with very fully in the author's recent Paper.[8] The actual cost of the addition of 1 per cent. of nickel comes to 35s. per ton of iron made up, and the cost for each percentage of chromium is about 14s. The average addition made is of 1 per cent. of nickel with or without 0.25 to 0.5 per cent. of chromium. Thus it is seen that about £2 will cover the cost of the alloy addition which is associated normally with the improvements discussed. For high-class irons this, it is felt, does not represent a very heavy percentage addition on cost, and, moreover, there is little doubt that in the near future alloy irons will definitely be regarded as superior materials by engineers, and a reasonable price covering any added cost in making the alloy addition will be paid for castings in this material. On the other hand, from the foundry point of view, it is being demonstrated that the alloy addition is often an economical proposition, since a cheaper metal mixture may be employed; and by working the improved grade of iron a reduction may be effected in the amount of scrap and waste castings. These latter points are of paramount importance to foundries which are working on the production of high-duty irons made up from so-called border-line mixtures; and it has been pointed out before that nickel irons are stable over a wider range of cooling conditions than are normal irons, and this tends towards more uniform production in foundries of this class

Nickel in Special Cast Irons.

From the general principles underlying the use of alloy elements in cast iron, it is apparent that improvements could be expected in all grades of iron-carbon alloys containing the higher quantities of carbon. It is to be expected that the higher the quality of the base material the better the results will be that are obtained by the use of alloys. Consequently, it is anticipated that such irons as "Nickel Perlit" will become more widely known, as the procedure of alloying will, it is expected, further enhance the valuable properties of castings produced by such processes. The same remarks, it is expected, will apply to other processes used for the production of special castings, but experimental work is only just being started in this direction, and it is hoped that results bearing on this subject will be available at some future date.

Conclusions.

Summing up the results of the recent researches on alloy cast iron (see also [9]), we find that certain general principles govern the choice of an alloy element. A preliminary consideration of the suitability of an alloy element, which clearly must take account of cost, alloying properties, and so on, limits to a very marked extent the number of elements which appear to justify further investigation. The next factor to consider is, undoubtedly, the influence of the given element on the relative stability of the combined and graphitic carbons in the casting, so that the desired general condition of the iron may be obtained. Next having adjusted the composition of the iron so as to produce the desired general condition, one must study the influence of the alloy element on the specific properties of the individual constituents of the structure of the iron, so that the additions may be made judiciously with a view to obtaining the best all-round results.

Experiments with aluminium in cast iron, which at first sight appears a promising alloy addition, gave disappointing results owing to the difficulty of oxidation of the aluminium in the iron. Consequently, this line has not yet been extensively followed up.

Experiments with nickel and with nickel-chromium have given definitely very promising results, and a general improvement in the properties of cast iron has been demonstrated by the judicious use of these elements, and these may very conveniently be summed up by a diagram. Fig. 3 gives the hardness values of a group of cast irons resulting from the use of alloy elements and control of composition. In this diagram one division to the right of point A corresponds to the addition of 1 per cent. of the element indicated, and one division to the left marks a corresponding reduction in composition.

The irons shown have compositions as nearly as possible similar except for the changes indicated, the hardness values are the mean obtained on the 1-in. and ½-in. steps of step castings. The composition of the base iron shown at point A is as follows:—

	Per cent.
T.C.	3.1
C.C.	0.67
Si	2.0
Mn	0.85
S	0.10
P	0.17

Given a base iron of this type nickel may be added to it direct, with a certain improvement in hardness as shown at B. This improvement is often accompanied by an improvement in strength and other properties, but in order to obtain the maximum benefit of the alloy addition further control of the composition is usually desirable. To obtain the best results in the alloy iron two courses are open to us. The first as shown by the points C and D involves initially a reduction in the silicon content of the iron to counterbalance the graphitising effect of the nickel In this case a marked all-round improvement of the iron is generally obtained. If, however, this silicon control is not a practical proposition, then, as indicated by points E and F, this same result may be obtained by the initial addition of chromium to harden up the iron, this being subsequently rendered machinable by the addition of nickel. The hardness value is here taken as typical of the general properties of the irons.

Alloy cast irons, in virtue of their improved properties, are finding extensive application in the engineering world for such castings as cylinders and cylinder liners for automobile engines, compressors, Diesel engines and pumps, and for pressure castings generally, for pistons, and for heat-resisting castings, moulds, etc.

It has been demonstrated that the marked improvement in properties, to which extensive reference has been made, can be obtained at an economic cost; and it is definitely felt that in the development of this class of material, industry has a tool which will materially help it to regain some of the trade which it has lost in the past few years through the insufficiency of its products. In addition, by increasing its reputation for quality production, the application of its castings may be extended, and this at a price compatible with the improved properties and service rendered.

It is well known that extensive research has been conducted recently on the subject of nickel cast irons in this country, and it is realised that the practical foundryman rarely has the time or the facilities necessary for applying the results of such research work in his own establishment. Accordingly, it is of great interest to see to-day the development of such an organisation as the Bureau of Information on Nickel, Ltd., which definitely sets itself out to assist the practical man in applying the results of research work involving the use of nickel. At this juncture it might be mentioned that the Bureau offers its services without charge or condition to anyone who wishes to try out or to follow up in his own class of manufacture this development of alloy cast irons containing nickel. Foundrymen need have no hesitation in coupling together the words nickel and alloy cast irons; for, judging by the results obtained up to the present, nickel appears definitely to be the one element which will prove of benefit in practice, and which has to-day no serious rival in this field.

In the future the foundryman may look forward to a time when cast iron will be restored to its own as eminently the most suitable material for many cast structures, and coupled with the restoration of this material to favour in the eyes of the engineer, he must associate reliability, with which control of composition is synonymous; and, moreover, in the specifications of composition it is to be expected that in the future alloy elements will find a prominent place for all high-class castings.

Newark Ironfounders Help Distressed Areas.

In connection with the scheme for migration from the distressed mining areas to more prosperous centres of industry, the ironfounders of Newark are to be complimented on the splendid way they have answered the call. Nineteen lads have been found work at Messrs. Ransome and Marles & Company, Limited, Messrs. Farrars' Boiler Works, Messrs. Blagg & Johnson, and Messrs. H. Mills, of Farndon Fields. The youths are under the supervision of the Local Advisory Committee for juvenile employment, of which Mr. Charles Stevenson is chairman and Mr. W. J. Spring is secretary. The lads under 18 receive a grant to supplement their wages. The money is chiefly expended in lodgings, which are recommended by the Committee. During the Christmas holidays the lads were able to visit their own homes as a result of a fund that was raised to buy the railway tickets.

Large Sums for Charities.

The employees and staff of Messrs. William Baird & Company, Limited, at their various iron works and collieries contributed during 1928 £8,552 10s. 8d. to infirmaries and other charitable institutions in Glasgow and the West of Scotland.

The employees of Messrs. Stewarts and Lloyds, Limited, Glasgow, at The Sun Foundry, Coatbridge, Clydesdale Iron and Steel Works, Mossend, and various other works, contributed during 1928 £4,899 6s. 7d. to various charities.

The employees of Cyclops Foundry and Pattern-making Company, Limited, Glasgow, have divided £19 7s. 6d. among charitable institutions in the city.

The employees of the Atlantic Engine Company, Limited, Wishaw, have allocated £93 12s. to various charitable institutions.

Employees of Messrs. Scotts' Shipbuilding and Engineering Company, Limited, Greenock, have contributed £605 to institutions in Greenock and Glasgow.

Aluminium-Silicon Alloys: Their Properties and Some Applications.

By R. B. Deeley, B.Sc., A.R.S.M.

PART I.—PROPERTIES.

(*Continued from page 32.*)

Specifications.

The specifications issued by the D.T.D. Air Ministry and by the Admiralty are shown in Table I. It is interesting to note how pure an

TABLE I.—*Air Ministry and Admiralty Specifications for Aluminium-Silicon Alloy Castings.*

	Air Ministry. D.T.D. 25.	Admiralty DNC/M/ 1 and 1A.
Composition :	Per cent.	Per cent.
Si. Between	10–14	9–14
Fe Not more than ..	0.75	0.6
Mn. „ „ „ ..	0.5	0.5
Other metallic impurities (not more than)	0.1 total	0.1 each.
Mechanical Test.—(On Test Pieces turned from 1 in. Chill Cast Bars):		
Ultimate strength not less than	12 tons/ sq. in.	11 tons/ sq. in. *
Elongation „ „ „	7 per cent. on 2 in.	6 per cent. on 2 in.*

* Test Bars may be cast in sand moulds when only 9 tons/sq. in. and 5 per cent. are required on test.

alloy is demanded by the Air Ministry, for it will be noted that in their specification the total amount of metallic impurities other than iron and manganese must not exceed 0.1 per cent.

The effect of other metals on the properties of the modified 13 per cent. alloy has been closely investigated by Welter[8], and the results he obtained show clearly how extremely sensitive these alloys are to the effect of very small quantities of added metals. The scope of the present Paper does not, unfortunately, permit of a reproduction of all the curves he obtained showing the effect of increasing quantities of the added metal on the tensile strength and elongation of the modified 13 per cent. silicon alloy, but the results may be briefly summarised by stating that, in general, progressively increasing additions of other metals cause a gradual decline in tensile strength and a rapid decrease in elongation. Table II shows the

TABLE II.—*Effect of Impurities on Modified Aluminium-Silicon Alloys.*

Element.	Amount to Reduce Elong. by 50 per cent.
Calcium	0.2
Magnesium	0.3
Copper	0.4
Zinc	4.5
Tin	0.3
Antimony	0.4
Manganese	1.0
Titanium	0.2

amount of each of a number of other metals, which, when present separately, will cause a reduction of 50 per cent. in the elongation of the modified alloys. It will be noted that, with the exception of zinc and manganese, the presence of a few tenths of 1 per cent. of any of the other metals shown in the table will ruin one of the most valuable characteristics of the modified silicon alloys—their ductility, and it will be appreciated that the strictest laboratory control must be kept on the chemical composition of the alloy, and that the utmost care must be exercised in the foundry to ensure that no scrap from castings in other alloys becomes mixed with runners, risers, etc., which are to be permitted.

Peculiar Foundry Characteristics.

The commercial aluminium-silicon alloys are one of the very few all-eutectic alloys ordinarily used, for, with the exception of the iron-carbon eutectic cast iron, the lead-tin eutectic or "tinman's solder," and possibly also the eutectic cadmium-zinc solder, all other alloys consist mainly of solid solutions, or only contain a small amount of eutectic. It is to this fact that the superior foundry properties of these alloys as compared with the other aluminium alloys is mainly attributable. The freezing ranges of a number of aluminium alloys in common use are shown in Table III, from which will be seen how small is the

TABLE III.—*Freezing Ranges of Aluminium Alloys.*

Alloy.	Primary Freezing Point. Deg. C.	Final Freezing Point. Deg. C.	Range. Deg. C.
12 per cent. Si Mod. ..	572	564	8
12 per cent. Si Unmod. ..	579	577	2
Y. Alloy (4 per cent. Cu 2 per cent. Ni[1] 1.5 per cent. Mg)	630	493	137
L.8 (12 per cent. Cu) ..	622	545	77
L.11 (7 per cent. Cu 1 per cent. Sn)	630	540	90
L.5 (13 per cent. Zn 3 per cent. Cu)	610	490	120

freezing range of the aluminium-silicon alloys and how large is that of the other alloys. The effect of this on the behaviour of the alloy in the mould, and, therefore, on the properties of the casting produced, is very important, and not always appreciated by those who attempt to work in these alloys. As was recently remarked by Mortimer[9], there is no other alloy as liable to provide pitfalls for the inexperienced and unwary, and this has been corroborated by at least one subsequent publication.

In considering the foundry properties, it will perhaps be best to commence with the design of the mould, for it is here that will be noted some of the more radical differences of the silicon from the other aluminium alloys.

When a mould has been filled with molten metal, and the mould is extracting heat from the metal and radiating it away, freezing commences at the surface where the metal is in contact with the mould. As heat is progressively lost, the skin of solid metal which first formed at that surface gradually grows in thickness as more and more metal solidifies on it until the whole thickness of the casting is solid. In the case of alloys with a large freezing range, the primary constituent which freezes at the higher temperature deposits first at the outer surface in the form of dendrites at right-angles to the surface. As cooling proceeds, the dendrites increase in length and in multiplicity of branches, and in the spaces between these branches those constituents which freeze at lower temperatures solidify as their freezing points are reached.

The dendrites are liable to trap small bubbles of gas, and also totally to enclose small quantities of lower-freezing constituents, which, on freezing, may contract so much that a void is left. The large numbers of small holes thus formed in other alloys are not found in the silicon alloys, which, since they are almost of eutectic composition, have no dendrites, and in which freezing takes place by a continuous wall of completely-solid metal growing inwards from the mould surface until all the alloy is frozen.

The design of the mould with regard to the position, size, and number of runners and risers and the size of the gates is in accordance with general foundry practice, with the exceptions indicated below. The fluidity of the aluminium-silicon alloys, even at temperatures but slightly above the freezing point, is so very much greater than that of any other aluminium alloy that runners can be cut down to a minimum that would be impossible in any of the other alloys, and, in fact, it is often customary, even with castings weighing as much as 5 to 6 cwts. with very thin sections, to use only one runner. In passing, it may be remarked that the great fluidity of these alloys makes possible the satisfactory running of very large castings of very thin section, which could not otherwise be cast in an aluminium alloy.

Table IV shows the thermal expansion, crystallisation shrinkage, and total contraction for a number of aluminium alloys, and it will be noted that while the thermal expansion is almost the

TABLE IV.—*Thermal Expansion, Shrinkage, and Contraction of Aluminium Alloys.*

Alloy.	Alpax Modified Aluminium Silicon.	L.5 13 per cent. Zn 3 per cent. Cu	L.8 12 per Cu	L.11 7 per cent. Cu 1 per cent. Sn	Y.
Thermal Expansion (Linear per 1 deg. C.) $\times 10^{-6}$	0.222	0.255	0.264	0.246	0.220
Crystallisation Shrinkage ..	3.8%	6—7%	6—7%	6—7%	6—7%
Contraction ..	1 in 96	1 in 78	1 in 79	1 in 83	1 in 77
„ (per cent.)	1.042	1.282	1.266	1.205	1.299

lowest, the total contraction of the silicon alloy is the smallest of all the alloys included in the table. The point of most importance, however, is that the crystallisation shrinkage of the silicon alloy is about one-half (3.8 per cent. compared with from 6 to 7 per cent.) that of the other alloys, and it is due to this in particular that silicon-alloy castings, if made in a properly-designed mould, are free from the shrinkage cavities found in castings of other alloys. It must not be forgotten, however, that since the alloys freeze over a very small range of temperature, this shrinkage occurs almost at one instant, and, if suitable steps are not taken to counteract it as it occurs, the cavities formed may be much larger than with the other alloys. An excellent example of the great care required in designing the mould, and how unsuitable for silicon alloys is a mould which is eminently suited to other alloys, was given by Archbutt, Grogan and Jenkin in their recent Paper[10] to the Institute of Metals on the "Die-Casting of Aluminium Alloys." The die they used at the commencement of their research was designed for ordinary aluminium alloys, and was totally unsuited for the silicon alloys, castings of which, made in the die, contained large cavities.

There is one other most important foundry characteristic of these alloys, and that is their almost complete freedom from hot shortness.

In the above-mentioned Paper by Archbutt and his colleagues they recorded the results they had obtained for the impact strength of aluminium alloys at temperatures near their melting points, and Table V shows some comparative values taken

TABLE V.—*Hot Shortness of Aluminium Alloys near their Melting Points.*

Alloy.	Temperature fall in deg. C. before energy to fracture is 10.9 ft. lbs.	Energy in ft. lbs. to fracture at 5 deg. C. below melting point.
12 per cent. Silicon ..	3	10.9
Y Alloy	11	4.7
8 per cent. Copper Alloy	24	0.7
2 L.5	45	0.5

from the curves given in that Paper. In the first column is shown the temperature fall below the melting point of each alloy that must take place before the alloys require 10.9 ft.-lbs. to fracture the particular sized specimen used. It will be seen that the 12 per cent. silicon alloy attains

this strength at 3 deg. C. below the melting point, as compared with 11 deg. C.—nearly four times as much—for "Y" alloy, while the fall for 2 L.5 is 45 deg. C.

It will now be appreciated that these alloys have peculiarly superior foundry properties as compared with other aluminium alloys. They are very fluid, and large castings of very thin section can be satisfactorily run, and when cast they are not liable to foundry cracks. It is for these reasons in particular, and also, but to a less extent, to their freedom from shrinkage cavities, that they are the only possible alloys for the manufacture of satisfactory castings of the type exemplified by railway-carriage doors.

Physical Properties.

The commercially useful silicon alloys contain from about 9 to 14 per cent. of silicon, and the optimum properties of strength and ductility are obtained with alloys containing from 12 to 13 per cent. silicon. In considering the physical and other properties of cast modified aluminium-silicon alloys, the values given are, therefore, in all cases those obtained from castings containing 12 to 13 per cent. silicon, unless otherwise stated.

The physical properties of the silicon alloys exhibit a number of peculiar characteristics, which, in different ways, show these alloys to be superior to other aluminium casting alloys for use in the cast state, and in considering these properties it is perhaps best to consider first the purely physical properties of the alloys.

Conductivity—Thermal and Electrical.

The thermal and electrical conductivities of aluminium and its alloys have recently been re-determined both at ordinary and at elevated temperatures by Griffiths and Schofield[11], and values taken from their Paper are given in Table VI. It will be noted that the thermal conductivity of the aluminium-silicon alloys is higher than that

TABLE VI.—*Thermal and Electrical Conductivities of Aluminium Alloys.*

Alloy.	Thermal conductivity Cal/cm/sec.	Electrical conductivity reciprocal microhms/cm³
Aluminium - Silicon Modified	0.41	0.25
Y Alloy (4Cu 2Ni 1½Mg)	0.40	0.26
2 L.8 (12 Cu)	0.38	0.23
3 L.11 (7 Cu 1 Sn) ..	0.39	—
2 L.5 (13 Zn 3 Cu) ..	0.32	0.20
Pure Aluminium ..	0.55	0.35
Copper	0.92	0.59

of any other aluminium alloy, and is, in fact, 75 per cent. of that of pure aluminium and 45 per cent. of that of copper. This appears at a first glance to be an adverse criticism, but, when it is remembered that the modified silicon alloy has a much greater strength than pure aluminium, it will be found that the heat conducted by the pure metal and by the silicon alloy through sections of equal strength is almost equal, and since this statement is based on a comparison of the strength of cast alloy with wrought pure metal, it would seem that there are large untouched fields of application for the modified silicon alloys. Though it is not possible to make the same comparison in the case of copper, it may be said that modified aluminium-silicon alloys have many points in their favour in their possible supersession of pure aluminium for replacing copper articles in such industries as food and chemical manufacture, where resistance to corrosion and certainty that material will not be absorbed from the containing or treatment vessels is of the greatest importance.

The electrical conductivity, it will be observed from Table VI, is almost the highest of any of the ordinary aluminium alloys, being slightly less than that of Y alloy, and considerably higher than that of 2 L.5 (13 per cent. Zn, 3 per cent. Cu alloy), and bears a similar relation to that of pure aluminium and copper as in the case of the thermal conductivity. Table VII gives a comparison of the relative cross-sections of conductors of aluminium and its alloys and copper, when the conductors have the same resistance, together with the relative weights of such conductors. Although the cross-section of aluminium and aluminium-alloy conductors must be larger than a copper conductor of the same resistance, a considerable saving in weight can be effected by the use of these light metals—aluminium affording a weight saving of 48 per cent., and aluminium-silicon alloy 28 per cent. This again suggests another possible field

TABLE VII.—*Comparative Conductivities of Aluminium and its Alloys and Copper.*

Material.	Resistivity Microhms/cm³.	Specific gravity.	Relative cross sectional areas of conductors for same resistance.	Relative weights of conductors for same resistance. Al=1	Cu=1
Copper	1.69	8.9	1.0	1.94	1.0
Aluminium ..	2.85	2.72	1.69	1.0	0.52
Al-Si Alloy ..	4.0	2.66	2.37	1.37	0.72
Y Alloy	3.8	2.79	2.25	1.37	0.72
2 L.8 (12 Cu) ..	4.4	2.88	2.60	1.63	0.84
2 L.5 (13 Zn 3 Cu)	5.0	3.0	2.96	1.94	1.0

of application for these alloys, for, although they are greatly used in a number of pieces or parts of electrical apparatus where lightness and resistance to corrosion are of primary importance, aluminium-silicon alloy castings, so far as the author is aware, have not been used primarily for their current-carrying capacity. It would appear from the above tables and calculations that there must be a large number of parts where lightness together with strength and good conductivity are essential characteristics.

Mechanical Properties.

In the consideration of the mechanical properties of castings in general, it is essential that some reliable standard be used for the comparison of one alloy with another, and, with this end in view, the British Engineering Standards Association specify that castings of aluminium alloys shall be represented by test-pieces turned from 1-in. diameter chill-cast bars. The results of tests obtained from such bars give an indication of the quality of the material in the casting, and, if the castings are made under uniformly good conditions, bear a definite relation to the actual strength of the alloy in the casting. With the ordinary aluminium alloys, the increase in tensile properties due to the grain-refinement produced by chilling, is fairly definite for each alloy, but in the case of the silicon alloys, that increase is far greater in the unmodified than in the modified alloys. This is due to the fact that casting the unmodified alloy in a chill mould causes partial modification to take place in addition to the normal grain-refinement to be expected from the increased rate of cooling. It will be seen from Table VIII, which gives the tensile properties of sand and chill bars of unmodified and modified alloy that the relation existing between the sand and chill bars in modified alloy is much closer than that existing in the unmodified alloy. It will be noted also that although the tensile values for the chill bars, both modified and unmodified, are not very different from each other, the modified-sand castings are at least 50 per cent. stronger than the unmodified. It will be appreciated, therefore, how misleading the chill test-bar can be as an indication of the quality of the alloy in a sand casting in silicon alloy.

In Table 9 are shown average values for the mechanical properties of 12 per cent. modified silicon alloy and for the four B.E.S.A. aluminium

TABLE VIII.—*Tensile Strength and Elongation of Sand Cast and Chill-cast Bars of 12½ per cent. Silicon Alloy—Modified and Unmodified.*

State.		M.S. tons per sq. in.	E. per cent.	Ratio: Chill to Sand. M.S.	E.
Unmodified	Chill Cast.	12–13	8	1.7	2.7
	Sand Cast	7	up to 3	1.9	
Modified ..	Chill Cast.	13–15	10—20	1.1	1.6
	Sand Cast	10–12	6 and upwards	1.5	3.3

casting alloys, Y, 2.L.5, 2.L.8 and 3.L.11, and in order to make a true comparison, values for sand as well as chill test bars are included.*

Considering chill castings first, it will be noted that the elastic limit and yield stress of the silicon alloy are comparable with those of the other alloys, except Y, while the fatigue range is superior to all other alloys except heat-treated Y. It is when the ultimate stress, elongation and impact strength are compared with the other alloys that the superior properties of the modified silicon-alloy become evident, for the ultimate strength is almost equal to that of Y alloy as cast, and superior to that of all the other alloys, while the elongation and impact strength are almost double those of L.5, which are the highest of the other alloys. In the case of sand castings it will be noted that the silicon alloy is stronger in every way than L.5, L.8 and L.11, and its ultimate strength is equal to that of Y alloy, while, though the yield stress is slightly lower, the elongation is many times greater than that of Y.

With regard to the possibility of improving the mechanical properties of the modified silicon-alloys by heat-treatment, it will be realised that but little increase of properties can be expected since the solubility of silicon in aluminium is about 1.2 per cent. at the eutectic temperature and decreases rapidly to 0.2 per cent. at 450 deg., remaining at this value right down to room temperatures. Archer, Kempf and Hobbs[12] have shown that the tensile strength and elongation of modified sand castings can be increased by about one-tenth by quenching in water after heating for a time at about 15 deg. C. below the melting point, but, as they point out, such heat treatment is not commercially applicable.

Welter[11] has shown that small additions of copper increase the dynamic properties of the modified alloy without serious effect on the tensile

TABLE IX.—*Properties of 1-in. Diameter Cast Bars of Aluminium Alloys.*

Alloy.	E. L. Tons/in.²	Y.P.S. Tons/in.²	U. S. Tons/in.²	E. per cent. in 2 in.	Brinell Hard.	Izod Impact. Ft./lb.	Fatigue Range. Tons/in.²
Chill Cast Bars.							
12 per cent. Silicon Modified ..	2.0	7.3	13.5	11	65	7.0	±3.8
Y Alloy (4 per cent. Cu 2 per cent. Ni, 1½ per cent. Mg) as cast..	5.6	11	14	1.5	85	—	—
Heat Treated	7.0	16	20	3.0	105	3.6	±7.0
2 L.5	2.8	4.5	13	5	70	4	±3.5
2 L.8	2.2	7	11	1	80	0.6	±3
3 L.11	3	8	10	3	60	1.4	±3.6
Sand Cast Bars							
12 per cent. Silicon Modified ..	2.0	7.0	11	8	52	5.0	±4.5
Y Alloy (4 per cent. Cu, 2 per cent. Ni, 1½ per cent. Mg) as cast	—	9.0	11	0.5	80	—	—
Heat Treated	—	—	16	1.5	100	—	—
2L.5	1.8	4.5	10.5	4	65	3.0	—
2L.8	1.8	—	9	1	75	0.6	—
3L.11	—	—	7	2	50	—	—

* The author is indebted to Mr. S. L. Archbutt for some of these figures which he found difficulty in obtaining, particularly for sand-cast Y alloy.

strength or elongation, in particular the resistance to repeated impact and to alternating stresses is considerably improved. Another improvement effected by the addition of a small amount of copper is the machinability which in the pure alloy is perfectly satisfactory if the correct form of tool be used, but is liable to cause a certain amount of trouble to the inexperienced if the correct form of tool is not used.

The tensile strength and elongation of chill-cast bars at elevated temperatures have been studied by Tapsell [12], who found that the tensile strength decreased steadily to 4 tons per sq. in. at 350 deg. C., while the elongation was unaffected at temperatures below 250 deg. C., after which a rapid increase took place.

It would at first sight appear that the modified silicon-alloy is not so suitable as Y alloy for use at high temperatures of the order of 200 to 250 deg. C. It must be clearly understood, however, that all the results so far published for the strength of these alloys at high elevated temperatures have been obtained from test pieces tested at the ordinary speed in the testing machine under the so-called "rapid loading test." Since most parts working at elevated temperatures usually have to withstand stresses continuously for long periods of time, it would appear that a better idea of the usefulness of the aluminium alloys at high temperatures could be obtained by a comparison of the maximum stresses which at any temperature they would withstand for an indefinite period of time—or, in other words, the limiting creep stresses at various temperatures. It would, therefore, seem advisable to omit further consideration of this point until the limiting creep stresses at various temperatures for the various alloys have been determined.

Chemical Properties—Corrosion Resistance.

Corrosion of aluminium alloys in general, and particularly those containing substantial amount of copper or zinc is due to the formation of local electrolytic-cells between individual crystals of differing electrochemical potential with the corroding-medium acting as electrolyte. The silicon-alloy being composed solely of aluminium and silicon, with the exception of a minute amount of iron which occurs as an unavoidable impurity, is not subject to the formation of these cells, and is, in fact, very similar to pure aluminium as regards its resistance to corrosion.

The alloy has been found in practice very resistant to atmospheric corrosion and large numbers of castings have given several years' satisfactory service, under conditions of atmospheric corrosion varying from those found in a smoky town to those on board ship. It is impossible to give precise details of the corrosion-resistance of aluminium-silicon alloys compared with other alloys since conditions of service vary so widely, but in order to obtain some idea of the comparative rates of corrosion, the author has suspended from a frame on the roof of his works, a number of cast plates of various alloys. Fig. 14

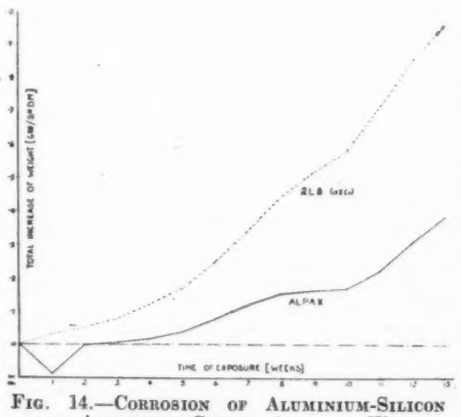

FIG. 14.—CORROSION OF ALUMINIUM-SILICON AND ALUMINIUM-COPPER ALLOYS. WEIGHT-INCREMENT-TIME CURVES.

shows the way in which "Alpax" (the 12 per cent. modified silicon alloy) and 2.L.8 increase in weight week by week, and it will be seen that the L.8 plate corrodes at roughly three times the speed of "Alpax." In order that the figure should not become too complicated, only these two curves have been plotted. The results obtained, however, show clearly that whether chill- or sand-cast, whether "as cast" or polished, and whether or no it contains 0.8 per cent. copper, "Alpax" corrodes at a very much lower rate than L.8, L.5, and an alloy containing 5 per cent. copper and 3.5 per cent. zinc.

With regard to other types of corrosion, it has been found that the modified silicon alloys are very resistant to sea water when erosion is not very marked. A test casting suspended half way between high- and low-water marks in the Clyde for six months was only slightly coated—not pitted—while the iron plates to which it was bolted had almost completely disintegrated. The silicon-alloy from a corrosion point of view, behaves in very much the same way as pure aluminium, and is very suited for making many articles which can be cast in one piece, but which would be difficult to build up from sheet. On account of this, large numbers of parts have been made for apparatus for use in the food industry—refrigerators, autoclaves, etc., and in other industries where lightness, strength, and resistance to corrosion are essential.

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Area Gas Supply Committee.

The Board of Trade have appointed the following committee:—Sir Alexander Walker, K.B.E. (chairman), Mr. Thomas Hardie, M.Inst.C.E., Mr. C. H. Lander, C.B.E., D.Sc., M.Inst.C.E., Mr. W. A. Lee, C.B.E., Mr. M. Mannaberg, Sir R. A. Pease, Bart., J.P., and Mr. S. Tagg, M.Inst.C.E., J.P., to undertake an investigation as recommended by the National Fuel and Power Committee in its report of September, 1928, in relation to a limited area, such as that between the Humber and Liverpool and between Leeds and Birmingham, respecting the technical and economic aspects of an area gas supply system, comprising an inter-connecting network of pipe lines fed by a number of gas works, coke ovens and the like. Mr. R. J. Moffat is the secretary and Mr. D. Haigh the assistant secretary of the committee. Communications should be addressed to the Secretary, Area Gas Supply Committee, Board of Trade, Great George Street, London, S.W.1.

Indian Iron and Steel Company, Limited.—The report for the six months ended September 30 shows an estimated trading profit for the half-year of approximately 30 lakhs of rupees, after paying debenture interest, but excluding depreciation, taxation, etc. The profit for the full year will be reduced by the stoppage of No. 2 blast furnace.

Metals Under the Microscope.

The London Junior Section of the Institute of British Foundrymen were given an interesting address by MR. B. F. BAKER, A.I.C., entitled, "The Examination of Metals under the Microscope," at their general meeting, held at the Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, W.C.2, on Friday, January 4.

Mr. F. C. Cummings presided, and apologised for the unavoidable absence of Mr. V. C. Warren, who was to have read a Paper that evening. They were very indebted to Mr. Baker for stepping in to fill the breach, and he felt sure they would all find the subject a very interesting one.

The lecturer commenced with a short historical survey of microscopy, pointing out that the examination of metals under the microscope was quite a modern science, the first attempt at testing in this manner being no earlier than about 1870, and was carried out by engineers who were attempting to discover the difference between chilled and soft steel. Practically no progress was made during the first twenty years, because after they had found out some primitive methods of polishing and saw something under the microscope they did not know what it was they were looking at.

Mr. Baker then described the modern method of preparing specimens for microscopical examination, going deeply into the matters of polishing and etching, and showing specimens at the various stages of the processes. The workings of a microscope were then explained with the aid of a large diagram. Finally, finished microphotographs were handed round the meeting for inspection, Mr. Baker pointing out the different constituents revealed in each.

A long discussion followed, during which the lecturer gave further valuable information upon the subject, and a hearty vote of thanks was afterwards accorded to Mr. Baker, being proposed by MR. CUMMINGS and seconded by MR. KENT.

Notification of Accidents.

Home Secretary Makes New Order.

The Home Secretary, in pursuance of Section 5 of the Notice of Accidents Act, 1906, has extended the provisions of this Act requiring notice of accidents in factories and workshops to be given to an Inspector, to the following classes of occurrences in a factory or workshop (including any place which, for the purpose of the provisions of the Factory and Workshop Act, 1901, with respect to accidents is a factory or workshop, or is included in the word factory or workshop, or is part of a factory or workshop) whether personal injury or disablement is caused or not:—

All cases of (1) bursting of a revolving vessel, wheel, grindstone, or grinding wheel moved by mechanical power; (2) breaking of a rope, chain, or other appliance used in raising or lowering persons or goods by aid of mechanical power; (3) explosion or fire causing damage to the structure of any room or place in which persons are employed, or to any machine or plant contained therein, and resulting in the complete suspension of ordinary work in such room or place or stoppage of machinery or plant for not less than five hours, where such explosion or fire is due to (i) the ignition of dust, gas or vapour, or (ii) the ignition of celluloid or substances composed wholly or in part of celluloid, or (iii) electrical short circuit, or failure of electical apparatus; (4) explosion or fire not included in paragraph 3 affecting any room in which persons are employed and causing complete suspension of ordinary work therein for not less than 24 hours.

This Order may be cited as the Dangerous Occurrences Notification Order, 1928, and came into operation on January 1, 1929, from which date the Order dated December 22, 1906, made under the quoted Section is revoked.

MR. PERCY STILL has given up the honorary secretaryship of the Diesel Engine Users' Association, after serving in that capacity for 15 years. His successor is Engineer-Captain J. H. Harrison, R.N. Mr. C. O. Milton, who has been co-honorary secretary for the last two years, will continue in that capacity.

Foundry Purchasing.—XXXI.

By Eric N. Simons.

Filing the Requisition Docket.

Only responsible officials are allowed to sign requisition dockets in proper purchasing departments, and the stores department has a list of those entitled to requisition for goods. When the storekeeper has issued the goods in accordance with the requisition, the dockets are passed to the stock record clerk, who deducts the corresponding quantities from his record cards. In fixing minimum quantities an average of consumption over a given period (usually three months) is taken, and the quantity necessary to keep in stock perpetually is worked out on whatever time-basis may be necessary. Thus, if the average consumption of bricks over three months is three thousand, and it is essential always to have a month's supply in hand as a minimum, the quantity recorded as the minimum will obviously be one thousand. After their contents have been noted down, the dockets are filed.

Date.	Article Issued.	Job No. or Symbol.	Check No.	Fitter.	Name of Person Lending.	Remarks and/or Signature.

FIG. 1.—NIGHT AND WEEK-END BOOK FOR STORES ISSUED.

As with deliveries, it sometimes happens that goods are required from stock after official hours, and in circumstances that make it essential to issue them without delay. A man working overtime on a rush job may need a tool, for example, and, in the absence of his foreman, he cannot get a signed docket. The stores officials have gone, and his only resource is to apply to the night watchman, in whose possession are the keys of the stores. These possibilities are provided for by keeping a night book for the issuing of supplies, and the watchman is instructed to allow no stores to be taken until the proper details have been inserted in the book, as shown in Fig. 1. In the morning this book is sent to the foreman of the department concerned, who makes out the official docket from the particulars given, if authentic. In this way no issue of goods escapes record.

If requisition dockets are received for goods that are not stored or stocked, the details are transferred to a purchase requisition slip, and this slip is sent up to the buying department so that they can be ordered. A record of these requisitions is kept in the form of duplicates of these requisition slips.

As has been pointed out in previous articles, in this particular system, each department has a series of symbols governing the subdivisions of its work, so that proper cost records can be kept.

Thus, repairs and maintenance, production, office supplies, are three well-marked divisions, each recognisable by a symbol. The stores department has to keep an accurate record of goods issued, with their values, to the various departments and departmental accounts, so that each account can in due course be debited by the cashier's office with the proper amounts. This record is kept on sheets similar to that shown in Fig. 2.

General Stores Issued.

Date.	Description.	Weight. C.	Q.	L.	Rate.	FAM.	FTR.	SWR.	SCR.	SFR.	PRS.	TTL.

FIG. 2.—STORES ISSUED RECORD SHEET.

These sheets are filled up from day to day, and the columns are added up at the foot and carried over on to the next sheet, if necessary. In this way the stores or accounts department can say at any moment what volume of materials they have issued over a given period, and the amount with which each different account must in due course be debited. This enables costing to be placed on a proper footing.

Taking Stock of Stores.

In some stores departments no proper stocktaking other than the annual one is instituted. The disadvantage of this is that it involves the department in a very heavy strain at the end of the year, the entire stock having to be checked over in detail, and errors investigated, all in one short period. In the instance under discussion, which can, of course, be modified, this is obviated by a simple expedient. A rough stock is taken by the storekeeper in person once every three months, and the details are entered in a book designed as shown in Fig. 4. Deficiencies and surpluses are thus revealed early, and when they are due to errors in the issuing of goods, or to failure to record deliveries from stock, they can be speedily detected and corrected, whereas over a long period of time, such as twelve months, they tend to become obscured by the multiplicity of transactions. For example, mistakes often occur through goods being issued, and then returned owing to their unsuitability. Replace goods are issued, and the returned materials put back into stock. The issuer forgets, however, to advise the record clerk of the change, and therefore the cards will show wrong totals. They will indicate a deficit of the goods that were actually issued, and a surplus of the goods that were marked down as issued, but were really returned. The stock book shown in Fig. 4 enables these errors to be detected at a glance and explained, with consequent amendations being made to the record cards. Thus, at the end of the year the stock, as shown on the record cards, is known to be nearly accurate, and final stocktaking becomes a short and simple matter. Two clerks make the fourth and final check, one calling out and the other noting down in memorandum books the details ascertained. These details are then entered in rough books designed as shown in Fig. 3. The column "old stock" gives the figures on the stock record cards, on, say, March 31, 1929. The column "new stock" indicates the result of the final stocktaking, dated April 1, 1929. The two figures constitute a check on each other. As a general rule they differ but little, and for stocktaking purposes a mean is struck between them. Thus, if "old stock" gives the stock of bolts as 40 cwts. and "new stock" gives it as 40 cwts. 3 lbs., the figure finally entered in the official stock book that goes up to the accounts department is 40 cwts. 1¾ lbs. It is estimated that this method reduces the time and labour of the annual stocktaking by two-thirds.

Date.	Size.	Description.	Old Stock.	New Stock.

FIG. 3.—STORES ANNUAL STOCKTAKING ROUGH BOOK.

Date.	Description.	Weight.	Quantity.	Card Record.	Surplus.	Deficit.

FIG. 4.—STORES STOCKTAKING BOOK.

Date.	Order No.	Kind of Package.	Sender.	Address.	Sent to	Signature.	Returned on

FIG. 5.—EMPTY PACKING CASE REGISTER.

Return of Empty Packages.

Another point on which the stores department concentrates with great effect is the return of empty packing cases, crates, barrels, etc., with a consequent avoidance of all charges for these. The system adopted is worthy of description, although in effect it begins in the accounting department and not the stores. As invoices for purchased goods are received, the cases or other packing receptacles mentioned on them are noted down in a book. The information this record contains is shown in Fig. 5. The book is then forwarded to the stores department. The departments that receive the goods are (unless the stores has actually unpacked them) held responsible for the containers. A packing case dump exists, and every Wednesday and Friday, between the hours of 11 and 12 a.m., a stores official is on duty at this dump to receive and sign for packing cases,

(*Continued on page 56.*)

Symposium on Steel Castings.

CLOSING DISCUSSION.

As a climax to the two meetings previously held and reported in full in our columns, the final meeting was devoted to a frank discussion of the present and future position of the steel-castings industry. MR. JAMES RICHARDSON, B.Sc., Chairman of the Glasgow and West of Scotland Branch of the Institute of Mechanical Engineers, again presided, and, in opening the proceedings, said that this was the third of a series of meetings held jointly with the Institute of British Foundrymen on the subject of steel castings. The first Paper was given by Engineer-Commander Sidgwick, who explained fully the position of the most important users of steel castings in an engineering sense, namely, the Admiralty. He also wished to encourage progress towards improvement in the quality of the castings that are being produced to meet their very stringent requirements, *i.e.*, resistance to high-temperature and high-pressure steam combined with lightness in weight and reliability. The Commander further indicated, and he (the speaker) as an engineer must sympathise with him on the point, that the castings must be light. He also put forward some very important pleas in support of his contention that the quality of steel castings must be as nearly as possible 100 per cent. perfect. He postulated that engine designers and builders would wish to use steel castings even more extensively than they do to-day if a supply of reliable, thin, and reasonably cheap castings were forthcoming. He further pleaded, with some conviction, that the requirements of the British Admiralty in demanding a very high grade of steel casting would enhance the prestige of British engineering, and would assist British engineers in their endeavours to capture trade the world over.

Engineer-Commander Sidgwick was followed by Dr. Pullin, who gave the results of his unique research work into the X-ray examination of steel castings. Dr. Pullin made out a very clear case for the thoroughness with which his X-ray examination reveals latent defects otherwise imperceptible in steel castings apparently sound. At the second meeting Dr. A. McCance indicated the physical and metallurgical difficulties in the way of producing sound steel castings from complicated designs, and he gave the laws to which steel conforms under the varying conditions of temperature from its passing to the final solidification and setting in the mould. Mr. Joseph Jefferson strengthened Dr. McCance's statements regarding the difficulties encountered, and stated that probably more reliable castings might be made if the founder went to the expense of melting more metal and making the mould in a different way, such as, for instance, flat or horizontally, with large headers and risers, instead of on end.

Six Cardinal Points.

He had provided six points that occurred to him as having arisen out of those Papers. Possibly, however, his stating these six points may be coloured from the point of view of the engineer or of the user of steel castings:—(1) What prospect has the engineer of more reliable steel castings, more particularly to meet the higher requirements as indicated by Engineer-Commander Sidgwick, and the more detailed and closer examination as foreshadowed by Dr. Pullin? (2) What prospect is there of thinner steel castings, also to be reliable, because if engineers can rely on thinner steel castings being reliable, then undoubtedly there is an unlimited market for steel castings to replace iron castings in all those branches of engineering where weight is of some importance? (3) Is the X-ray evidence put forward by Dr. Pullin, for the first time to his knowledge, accepted by the steel-founding industry? (4) Can the composition of this steel not be varied to suit the particular type of casting to be produced? He put this forward in ignorance of the metallurgical aspect of the production of sound steel castings, but he did know that for different types of ships different types of engines had to be designed, just as for different maladies different medicines had to be taken. Possibly various compositions of steel could be used to produce satisfactory results and to meet the varying degrees of complication. (5) It cannot be without interest to the steel-founding industry to know to what extent X-ray analysis will be specified by those authorities who were responsible for the purchase of large quantities of steel castings per annum. (6) Lastly, how is the engineer best to co-operate with the steel-founding industry? Should there not be brought into being some central authority, some clearing-house as it were, to deal with the various problems with which the founder and the engineer are beset?

Steel Castings can Show Properties Equal to Foreign.

MR. J. S. BROWN said the four Papers which had been presented to this conference form a very valuable summary of the position of steel castings in British industry. It had been shown that there was an increasing demand for such parts in modern power plants, and that progress in the development of these power plants was being restricted by certain limitations in the founders' art. In reply to this the steel makers had explained the exact nature of their present difficulties, classified as lying in the characteristics of the steel during cooling in the mould, in the destruction of the refractories forming that mould, and in the ever-present question of costs. While it was not possible to make suggestions which would remove limitations, it remained necessary to point out that the representatives of the users had raised little objection to increased costs; and the evidence they had submitted of excessive wasters discloses in itself that a fair return could be earned on any increased care which would insure that the moulding costs only arose once for each casting.

To encourage developments in this direction it might be of some service to the steel founder again to review the qualities in his product which the user found of value; and the following was a resumé of that position. The steel casting took the place of both cast-iron and gun-metal on entering the range of the higher steam temperatures in boiler work; it appeared in the pistons and cylinder heads of the Diesel engine; and it had a wide and increasing scope in all situations where the weight was important. Its merits in the high-temperature field arose from a definite superiority in its strength qualities; and the Department of Scientific and Industrial Research had recently published detailed reports on tests of a series of cast steels showing tensile, creep and other qualities which are almost identical with the corresponding forged steels of similar carbon content. (Engineering Research Report, Nos. 1 and 2, May and July, 1927.) From this position the user would be willing to substitute steel castings in almost every position where forged steel is being used, and would find immense advantages in the flexibility of form given with the casting; and if he did not proceed fully in this direction it was because of experience that the actual castings fell below the standard of the small test-pieces on which the above tests were made.

Continental Competition and the Electric Furnace.

There was another side to the question of the quality of steel castings in the fact that certain Continental foundries were able to maintain a position in the markets of this country; and in the case of motor vehicle items, such as axle casings and wheels, this market continued in spite of the 33 per cent. import duty. There was no use in disguising the fact that Britain was an importing country, rather than exporting. This showed that the Continental founder can offer a product which better met the requirements in certain directions.

Does this arise from certain differences in technique such as the Continental use of electric melting? It had been stated that the electric furnace may actually increase the difficulties due to the charge being too pure; but this could not be a complete explanation, for the purity could be adjusted in a downward direction with great ease. And, further, the firm of Leyland Motors, Ltd., have installed their own electric steel-melting furnaces, and experience a brisk demand for their surplus capacity from other branches of the engineering industry.

Reviewing the position as a whole, it would appear that this country had some leeway to make up in the progressive development of casting in steel. The user had been pressing the founder to this end since 1885, when the Institution of Naval Architects had a Paper on Cast Steel Crankshafts; but these crankshafts had not yet arrived, and one was led to ask whether there was not scope for some intensive research into all the problems; what detailed analysis is present practice being subjected to in the light of Continental results?

This would doubtless involve a considerable financial expenditure, but the industry could expect to be supported by the Government research organisations. Indeed, this position was already arising, for the latest Report of the work at the National Physical Laboratory showed that they are investigating gas inclusions in steel castings, and that they were using electric melting in preparing the steel. It would be of great service for the industry to encourage this work; to see that its scope included the actual difficulties met with in practice, and to broadcast the final conclusions as fixing definite limits to the sections and proportions which can be obtained with success.

An Inspector's Views.

MR. J. L. ADAM said it was largely against his own convictions that he joined in the discussion, because he represented an inspection department, and, while he found defective castings, he was rarely in a position to say how they should be avoided. One of the things he liked in Dr. Pullin's lecture was his reference to the service which might be rendered by the use of the X-ray in examining the first few specimens of a large batch of castings, and so discovering a method of remedying any defects which might appear. He had the same trouble as the Admiralty, only to a different degree, probably due to the fact that he had more latitude in the matter of weight, but he had trouble where conditions approximated to those of the Admiralty, as, for instance, in hollow castings of comparatively low scantlings, such as steam pistons of the box-pattern.

Steel Castings for the Merchant Marine.

ENGINEER-COMMANDER SIDGWICK did not deal with ship castings, but to some extent these are even more troublesome in merchant service than are engine castings. Larger masses of material were dealt with having more rapid changes of section, and, as a consequence, steel castings for sternframes of the "U" or trough section earned a doubtful reputation, and he was not sure that in some minds the doubtful did not still remain. In particular this applied to castings forming the heel of sternframes where the section changed from a "U" or trough-shaped form with two arms into the solid mass formed by the shoe of the sternframe. All Mr. Jefferson's remarks on the necessity for avoiding rapid changes of section are no doubt perfectly true, but in ships of the ordinary design for merchant service it was a little difficult to see how such castings could be avoided, and this applied also to the design of spectacle brackets.

Futility of the Hammering Test.

In the ordinary specification relating to steel ship castings, the pious opinion was given that steel castings, where intended to be used for forgings, should be so designed as to avoid abrupt changes in sectional area. Each casting must be thoroughly annealed and subjected to percussive and hammering tests, as well as tests for tensile strength, ductility, etc. It was also stipulated that the test-pieces were to form part of the actual casting submitted for approval, and are to be subjected to similar and simultaneous anneal-

ing. If he understood Mr. Jefferson correctly, despite such precautions the results obtained from the test-piece may give little or no indication of the actual strength of the casting. Engineers had all experienced cases where the tensile tests from a casting had been perfectly satisfactory, and yet when the casting (in the particular case in mind, it was a heavy fore-foot casting) was dropped through an angle of 45 deg. it broke through the "U" section. He would appreciate some information as to the value of hammering tests. The usual specification in regard to ship castings required that they should be slung clear of the ground and well hammered all over with a heavy sledge hammer. So far, at least in recent years, he had not been able to obtain particulars of any casting being rejected as the result of this hammering test, although rejection of castings on account of defects, mostly understood to be due to "draw," were common enough.

A great deal had been said about defects found under testing conditions, and various tests have been described. If such information was to be of any use for the purpose of these discussions it could only be by an analysis of the results of the tests which would show the why and the wherefor of any defects, because many engineers could find a defect and not be able to say how it could be avoided.

Co-operation as Basis for Improvements.

MR. W. E. LEWIS said that Engineer-Commander Sidgwick had put forward the point of view in favour with the Admiralty, and probably mercantile and marine engineers as well. Undoubtedly, however good steel castings were at present there was room for improvement, and any possible improvement would be the result of the co-operation initiated by this Joint Meeting. If we could find some method by which defects could be traced and localised, many of the difficulties confronting both engineers and steel founders would disappear. Referring to the chairman's Point No. 6, how was this improvement to be obtained? The secret of the whole business was co-operation. Everyone of the speakers mentioned that, and only by co-operation between the departments interested in the production of steel castings can the most efficient results be obtained. Dr. Pullin had shown that it was possible now to have an apparatus by which the interior of a steel casting could be examined. The problems that were facing the industry recalled the problems that were facing the users and the makers of steel chains and cables before the passing of the Cable and Chain Act. Users were not satisfied with the product, but the users and the makers got together and a specification was drawn up, various centres (the Proving Houses) were established to assist the maintenance of this standard, with the result that in a very short time afterwards the quality of British chain cables became second to none in the whole world. He suggested that the Admiralty, as the biggest users of steel castings, might do something in that line themselves. It was impossible to ask the steel founder to erect X-ray apparatus in his foundry, but would it not be possible to establish X-ray centres, in Glasgow, say, and in other large industrial centres, to which the founder could send his casting and have it examined by an expert and a report thereon prepared and sent to him. That would then form a basis by which both makers and users could get together. Another matter in regard to which co-operation is very necessary, is between the designer and the founder. The third person to whom co-operation was most important is the independent pattern maker. The last was the most important of all, because he had to transform the engineer's wishes on paper into something concrete for the foundrymen to work upon, and he knew from bitter experience how great the need was for this co-operation. He had had patterns sent into the foundry when he was engaged in the business from which it was really impossible without a great deal of modification to make a decent casting. The more the metallurgist and the steel founder co-operated the better would be the results reflected in the product. Finally, the founder should co-operate with all the others, so that the results of their work should not be lost. Unless care is taken in the foundry, the efforts of all the others, the designer, the pattern maker, and the metallurgist are absolutely thrown away, and he thought there was no part of the work where that neglect receives more drastic retribution than in steel founding; and from experience with castings he had found that the greater number of replacements that he had was due to such faults as sand holes, etc. If these faults could be eliminated, and according to Mr. Jefferson's Paper they could be eliminated, then 50 per cent. of the engineer's troubles would disappear, and the people whose duty it was to attend to the castings would find that the other 50 per cent. would disappear.

MR. T. M. SERVICE limited his remarks to the Paper given by Commander Sidgwick, for the reason that he dealt with the Admiralty views which were the result of large experience. Further, in the case of Admiralty castings for high pressure purposes, no patching, either by welding or other means, was permitted, consequently the castings as cast must be perfect both superficially and internally. Commander Sidgwick in the early part of his Paper, outlined the Admiralty requirements, and, at a later stage, showed how the steel founder failed to meet the specification, and gave seven types of failures as illustrations. At a still later stage in his Paper, Commander Sidgwick pointed out the Admiralty desired to help the steel casting industry, and by their stringent supervision tried to improve the quality, and as a result reduced the weight of the various parts in naval ships.

He, the speaker, had condensed the Admiralty requirements into three main issues and proposed to analyse these and show how the Admiralty assisted, or otherwise, in attaining their ideals. The three points were:—(1) Quality of material; (2) reduction in weight; (3) homogeneity.

Admiralty Specification Deemed to be Low.

As to the quality of material, it was interesting to note the following specifications:—

Admiralty:—*Ultimate tensile strength*, 26 to 35 tons per sq. in.; *elongation* on 3 in. 15 per cent.; and *bend*, 60 to 90 deg. on 1 in. sq. bend.

Lloyd's and B.E.S.:—*Ultimate tensile strength*, 26 to 35 tons per sq. in.; *elongation* on 3 in., 20 per cent.; *bend*, 120 deg. on bend, 1 in. × ¾ in.

In the case of two valves, the walls were only ¾ in. thick and the walls comprised the greatest area. The founder had to cast a test-bar sufficiently large to obtain a 1 in. × 1 in. for bending purposes. He had been under the impression that the object of testing was to obtain the average physical properties of the bulk of the material and this could be more nearly met by test bars of the dimensions given under Lloyd's and B.E.S. specification.

If the Admiralty required the highest quality of steel, would Commander Sidgwick explain why the Admiralty Specification was the lowest of all the British Surveys?

Lightweight Valves and Heavy Brackets Exhibited.

As to reduction in weight he exhibited models of two valves, one 10½ in. and the other 11½ in. The weight of the first, without brackets, was 7 cwts., and the weight of the brackets was 1¾ cwts. The second valve, without brackets, weighed 10½ cwts., and the brackets weighed 2½ cwts. That meant, in order to attach the valves to the ship's structure, a further additional 20 per cent. in weight was required. The thickness of the valve walls, which were exposed to high-temperature high-pressure steam was ¾ in., while the thickness of the brackets which were required to attach the valve to the ship's structure was as follows:—

10½ in. *valve* ... Supports ⅞ in. and base 1⅛ in.
11½ in. *valve* ... Supports ⅞ in., base 1¼ in. thickened in places to 1⅜ in.

If the Admiralty were serious in their attempt to reduce weight, why should the important part of the casting be sacrificed? Surely it was not the skill of the designer so to design the valve that the important parts should not be harmfully reduced but the major reduction in weight carried out on the less important.

Homogeneity of Steel Castings.

Designers do not seem to appreciate the physical changes which take place in steel when cooling from the fluid to the solid. In addition to lineal contraction there was also volume contraction, and accompanying this volume contraction there were also the chemical changes which, with certain compounds, lead to heterogeneity, the degree of which depended on the mass and speed of cooling.

That the above laws were not understood by designers was illustrated in the 10½-in. valve, where two 7⅞-in. brackets met at a point on the ¾-in. wall, with the result that an area of retarded cooling is produced which becomes a potential source of hot tearing. In addition to the danger mentioned there was also the possible danger of an internal weakness, due to the fact that the surrounding metal was solid before volume contraction in this area was finished. By an alternative in design this difficulty could be minimised.

If one examined the valves internally, one found a circular valve seat which, with machining allowance, has a cross-section of 2 ins. × 2 ins. = 4 sq. ins. This seat was connected to the valve opening by a ¾-in. thick wall. It was obvious that the ¾-in. wall would be solid before the volume contraction was completed in the valve seat and consequently a contraction cavity would occur.

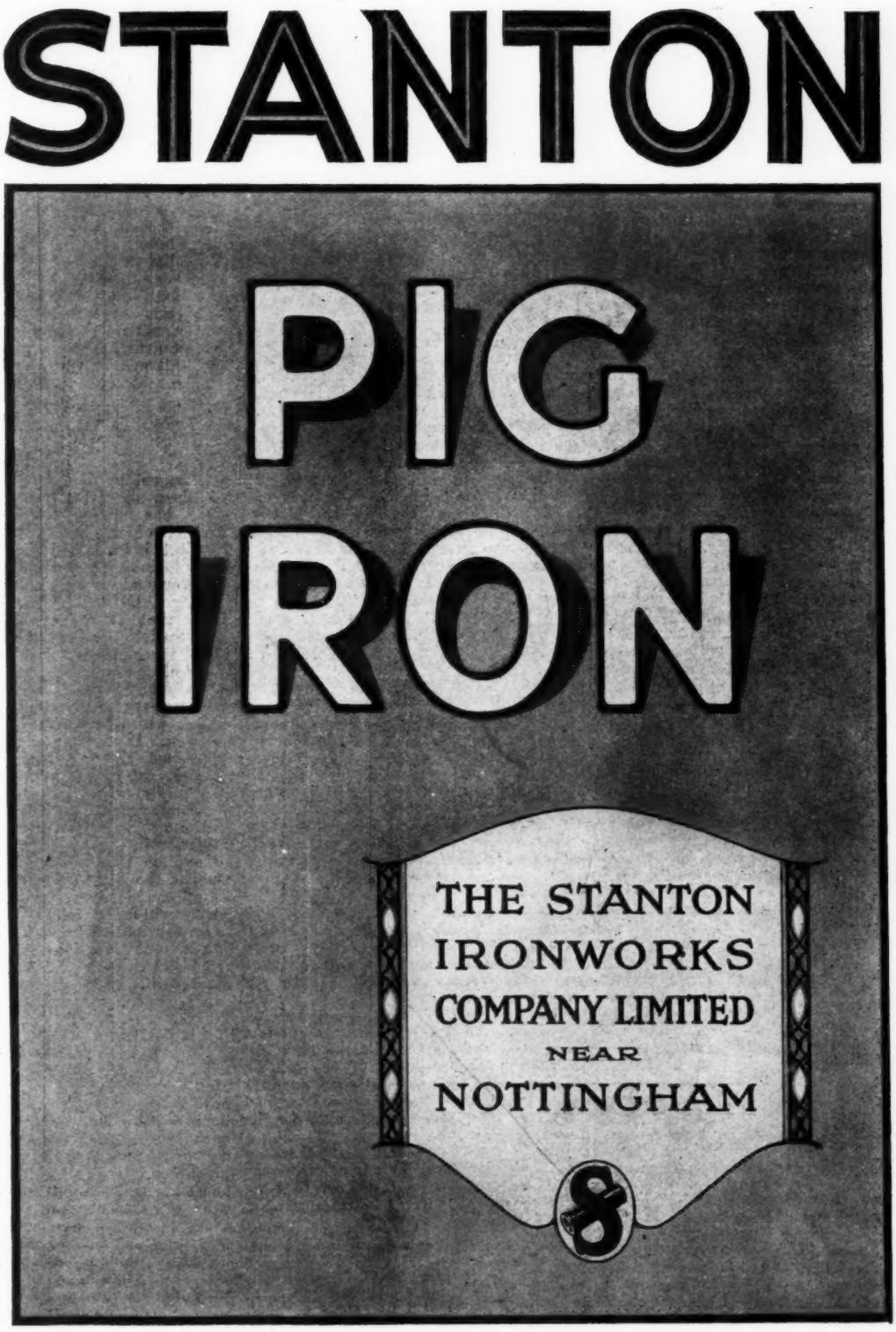
These remarks were based on the two models submitted, but many more Admiralty designs could be discussed and shown to have equally bad features. He was aware that some of the defects mentioned could be minimised by the use of chills, a point on which he had not touched, but one must remember that the Admiralty ask for castings free from defects externally and internally, and chills in many cases set up defects equally as serious as the ones mentioned, and as welding or other forms of repairing were not allowed, the castings, even if chills had been used, would be equally unserviceable. The steel founder was to blame in the respect that he had blindly accepted designs without question, while he should, instead, have pointed out the objectionable features. As a case in point, his firm took a very strong stand in the case of an Admiralty design, and had it altered to bring it within manufacturing capability and accessibility for inspection, with the result that satisfactory castings, both from the Admiralty and founder's point of view, have been produced.

Steel Gearing for Sugar Machinery.

MR. A. A. ARNOLD said that one of the many uses for steel castings in the construction of sugar machinery was for the heavy spur wheels and pinions used for the reduction gearing driving the sugar mills, and for pinions on the mill rollers themselves. The teeth of such gears were now universally made as steel castings, either with machine-moulded cast teeth or machine-cut teeth, and it was not only on account of their strength that steel should be used, but for its wear-resisting properties. The service in the case of pinions on mill rollers was most strenuous, amounting, in some cases, to estimated pressures of, say, 2,000 lbs. per in. width of tooth face, or possibly more, and under very difficult conditions, because the centres between the shafts might change slightly in the course of working, due to increased openings between the rollers. The tooth speeds were low, being between 20 and 40 ft. per min., but the service in many cases was continuous throughout a whole week. The reduction gearing, however, had fixed centres between shafts, also low tooth speeds, the first motion being in the neighbourhood of 300 ft. per min., with tooth pressures up to 1,600 or 2,000 lbs. per in. of width, and the second motion about 100 ft. per min. with tooth pressures up to as much as 3,000 or 4,000 lbs. per in. of width. There were, of course, cases of much higher tooth speeds, with machine-cut teeth, and the present tendency is in that direction. Steel gears with machine-moulded teeth, after a service of nearly 20 years (five to six months' season per year), have shown very little signs of wear, which indicates that both strength and wear-resisting requirements had been satisfied. The defects to which such castings may be subject is more apparent than real, but in some cases one would like to see smoother surfaces, especially for the contact surfaces of the teeth in machine-moulded wheels and pinions.

Resistance to Wear.

Further, castings made by steel founders of the highest reputation were sometimes very ragged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along the edges of the wheel arms as though the metal were sluggish in the mould. Regarding resistance to wear, he had, on the other hand, seen many cases of machine-cut cast-steel gears working under similar conditions of service at the low tooth speeds already given, and in some cases actually alongside the machine-moulded gears on adjacent sugar mills in the same factory; the machine-cut gears had shown signs of distress by the teeth edges spreading sidewise, indicating that the material was somewhat soft, possibly due to the cast surface being removed and exposing the internal metal which might have been of a softer character. Some pinions had been, in a short time, so much worn in this manner that they had to be reversed on their shafts so as to present the opposite face of the teeth as the driving side. There was usually nothing objectionable in this procedure except the expenditure of time, which was important in a sugar factory, and the labour of doing so. When this spreading out takes place obviously the contour of the teeth becomes altered and imperfect, under which conditions rapid wear must take place. In one case in point, the first motion gears were stated to require entire replacement every season after working about six months. It was only fair to state that in all the cases mentioned the machine-cut steel wheels and pinions were supplied by manufacturers in the United States and not from this country. He would not say that this was the reason of the want of durability, perhaps others could say. One defect, if it may be called such, was that some steel founders, and only some of them, remove core prints from the patterns and omit cores so that hollow parts are cast apparently solid and additional machining was therefore necessary. It saved the inconvenience of badly-cored castings, but incidentally it reduced the anxiety of the steel-founders of the risk of misplaced and displaced cores and saved them the necessity of exercising care while increasing their weight output and the cost of the casting to the machinery manufacturer. It also produces "fuzzy" places or hollows in the interior, such as Mr. Jefferson had outlined. Cores of small cross-section may be fused up, it is true, but it was not to these that he referred. Was the designer to be blamed or not for defects arising from this cause? As a matter of interest he would like to raise the question of the strength specification for steel castings. It would be remembered that in the days gone by, for wrought steel it was specified that the tensile strength should not be less than so many tons per sq in. and not more than so many tons per sq. in. with a certain minimum elongation in a certain length. In most standard specifications this style seems to have disappeared and the tensile strength is required to be between certain limits or to have a minimum value with a corresponding minimum elongations. There were, however, exceptions, as in the case of crank webs for marine engines if made of cast steel.

Both Lloyd's and the Board of Trade rules state that the tensile strength must *not exceed* 32 tons, and further the sum of the tensile strength in tons per sq. in. and corresponding elongation on a standard test piece shall not be less than 50 per cent. From this it would seem that steel castings of the highest tensile strength, with suitable elongation for all grades A, B and C which were in accordance with the British Engineering Standards Association specification for marine purposes, were unsuitable, because their tensile strength exceeds the figure already stated. Should the inspector reject such castings for this purpose, even supposing that the obtained tensile strength of 35 tons was reckoned as only 32 (the limit) when added to an elongation of 20 per cent. making a sum of 52 against the 50 required, that was to say, was steel of 32 tons and 20 per cent. elongation suitable and steel of 35 tons and the same elongation—20 per cent.—considered unsuitable, and if so what was the reason? Commercially it was not possible to have tensile and other tests made for all castings, how, then, was the engineer to know when the castings supplied have been satisfactorily annealed? He was surprised to learn from Commander Sidgwick's Paper that steel castings, for superheated steam, were first used by the Admiralty in 1923, as 20 years before that there was occasion to put in a stop valve for superheated steam which was specified to be of gunmetal, because the Admiralty always had gunmetal stop valves. The consulting engineers to the Admiralty (it being a land job) were requested to allow a stop valve with cast steel body to be supplied instead, and that was done.

Views of a Locomotive Engineer.

MR. C. H. ROBINSON said the subject of steel castings was one of great interest to locomotive engineers. A considerable proportion of the weight of the present-day locomotive was composed of steel castings, which amount to from 15 to 20 tons, in the case of standard gauge express engines, such as the L.M. & S.R. "Royal Scot" and L. & N.E.R. "Pacific" classes. This figure tended to increase to the elimination of heavier iron castings, which were being substituted by steel of lighter sections, and of plate and angle stretchers which were not so rigid. In this country the plate frame was universal, but in the U.S.A. the bar frame held the field. The latter was always made of steel castings in that country, but where used on Dominion or foreign railways, which were controlled by British boards and engineers, there seemed to be a diffidence to use this material, and it was almost universally specified that they must be ripped out of solid rolled steel slabs. A pair of bar frames for a medium-sized locomotive weighed about 10 tons in the finished condition.

Some few years ago some very heavy engines of the bar-frame type were built in this country for South Australia, and the frames were cast in America. Whether this was a question of price or diffidence to undertake the work on the part of home founders, he did not know, but it was not very inspiring to see such work going abroad. Recently inquiries were circulated for some heavy locomotives for another Australian railway, and it was specified that the frames and stretchers should be "cast in one." The whole structure was designed as a "box section," and the total weight of the casting, a very complicated one, was 16 tons. These were actually specified to be cast in the United States.

Steel Castings from the Machine Shop.

Considering steel castings from the machine-shop point of view, he had noticed a considerable difference in the quality of home as against continental castings. The continental casting was usually "milder" and seldom suffered from two defects, serious from the machine-shop aspect, which were frequently missing in home castings, namely, "hard spots" and "sand inclusions." The "hard spots," which occurred in segregated patches were a serious drawback, as a reasonable cutting speed was impossible owing to the liability of breaking the tool, and they often had to be chipped out with a sharp-pointed chisel, causing a great waste of time. "Sand inclusions" were also the cause of serious delays, as the tools were blunted and had to be removed frequently for regrinding. These two defects prevented the use of milling processes, owing to the risk of ruining expensive cutters. Judging from machine-tool makers' catalogues and articles in the technical Press, which boom the successes of the milling machine in America for finishing steel castings with wonderful production times, one imagined that castings free from these defects must be the general production in that country.

He had noticed that the contraction allowance on patterns for continental foundries was very much greater, sometimes almost double, that required in this country. It would be interesting if Dr. McCance could enlarge upon this.

Failures of steel castings in locomotive operation were, in so far as his experience went, infrequent. He had known of one or two cases of stretchers cracking, but these appeared to have been "hot tears," which had not come through the skin, until submitted to stresses in service. He once inquired of a friend, who was chief mechanical engineer of a railway which possessed a large number of locomotives, whether he had had any experience of a cast-steel wheel centre failing in service, and the reply was "never." This was certainly to the credit of the steel founder, as he imagined that a wheel centre, with its heavy boss and spokes tapering into a comparatively light rim, must be the very worst type of casting to make good, judging from the remarks made by Mr. Jefferson.

He regretted that none of the Papers had dealt in any way with alloy steels. Judging from the technical Press relative to locomotives, they were being much used and discussed in the United States, particularly for bar frames and heavy stretcher castings. It would be interesting to know the effects of the various alloying constituents, and to what extent they were being used in this country.

(*To be continued.*)

Trade Prospects at Bo'ness.

In forecasting the prospects in the iron trade for the coming year a prominent Bo'ness iron-founder said that a fair quantity of orders had been booked, and it was a case of carrying on until better times came along. Bo'ness foundries specialise in light and heavy general castings, and they have to contend with severe competition from the English and foreign makers. Prices are not altogether remunerative. Comparatively few workmen have been paid off during the past year as recourse has been had to short-time working, and this will be the rule for this year unless there is a considerable trade revival.

Falkirk Strike.

A sequel to the strike of rain-water moulders, of whom about 1,000 are involved in the Falkirk area, has followed in the suspension of a large number of workmen engaged in other and dependent branches of the light casting industry, these including patternmakers, fitters and dressers.

Arrangements are being made to accelerate the taking of the ballot vote of the men concerned in order that their attitude may be ascertained at the earliest possible moment. An interesting point in connection with the ballot has arisen in view of the opinion that has been expressed in some quarters that a two-thirds majority would be necessary to reverse the result of the previous ballot, which was overwhelmingly against the reduction. It is pointed out that this view is erroneous, the true position being that unless a majority of two thirds declare for a continuance of the strike in the present ballot the men will return to work.

The officials of the unions, while anticipating a majority in favour of strike action, are generally of opinion that the majority will be considerably smaller than at the previous ballot, and are not at all confident that the requisite two-thirds majority will be given.

In the meantime most of the works are meeting current orders from heavy stocks of rain-water goods which have accumulated during the recent slack spell.

Foundry Purchasing.—XXXI.

(*Continued from page 52.*)

etc., returned by the various departments. Cases have to be returned in good condition, and if any department fails to send a case back, or sends it back to the dump in a damaged condition, the matter is reported and an inquiry is held. But into the intricacies of administrative discipline one need not go. If search fails to discover a case, or through negligence it has become too badly damaged to be returned, the department responsible is *debited with the cost.*

Any container discovered to be damaged on arrival is at once reported to the stores, who in turn notify the traffic department. The latter then report the damage to the sender and the railway company, and leave them to discuss the responsibility with each other. The stores official during his period of duty at the dump has with him the packing case book, and carefully marks off in the space provided each container returned. When a large enough number of cases has been accumulated, the traffic department is communicated with, and asked to provide a truck for their despatch to the various destinations.

This system has reduced the item "missing packing cases charged for" to an almost negligible sum in the annual accounts.

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Trade Talk.

THE JAPANESE PRODUCTION of steel in 1928 is estimated at about 2,000,000 tons.

THE INDIA STORE DEPARTMENT has placed an order with Messrs. Sir W. G. Armstrong, Whitworth & Company, Limited, for a light vessel for service at Rangoon.

MESSRS. PRENTICE, SERVICE & HENDERSON, Glasgow, have placed an order for a steamer of about 9,000 tons dead-weight capacity with Messrs. Barclay, Curle & Company, Limited, Whiteinch and Scotstoun.

MESSRS. THOMAS LAW & COMPANY, LIMITED, Glasgow, have placed an order for two steamers, each of 9,000 tons dead-weight carrying capacity, with Messrs. Charles Connell & Company, Limited, Scotstoun.

ALLOY WELDING PROCESSES, LIMITED, have secured a contract from the Assam Bengal Railway Company for the supply of a motor-generator electric-arc welding plant for two operators.

THE NORTHAM IRONWORKS of Messrs. Day, Summers & Company, Limited, Southampton, were sold by auction recently to Messrs. George Cohen, Sons & Company, Limited, London, for £25,000.

THE RIGIDUS BOAT COMPANY, LIMITED, Glasgow, have received an order for a 70-ft. twin-screw motor yacht, to be built on their patent Rigidus system and fitted with two Gleniffer engines. The vessel is for a client on the Clyde.

MESSRS. RICHARD THOMAS & COMPANY, LIMITED, will shortly bring into operation their steelworks at Scunthorpe, which have been idle for more than three years. It is hoped during the current month to start two open-hearth steel furnaces working.

THE LINTHORPE-DINSDALE SMELTING COMPANY, LIMITED, have decided to restart a blast furnace at their Middleton Ironworks, where there are four furnaces, one of which is already in blast. The furnace to be relighted will produce ferro-manganese.

DURING THE past twelve months about 30 large vessels have arrived at the Prince of Wales' Dock, Workington, with foreign ore, and the imports for the year have amounted to 115,330 tons. All the ore was consigned to the United Steel Companies, Limited, at Workington.

WITH THE main object of bringing together the asbestos-cement interests of Bell's United Asbestos Company, Limited, and Turner & Newall, Limited, an amalgamation between the two companies has been effected. In packings, jointings and general engineering supplies, it was not found possible to harmonise the sales policies of the two concerns and their subsidiaries and, therefore, the goodwill in this trade has been disposed of to an independent company trading under the style of "Bell's Asbestos and Engineering Supplies, Limited."

We understand that Messrs. Thos. W. Ward, Limited, Sheffield, have acquired from the receiver, the Carbrook Steelworks, presumably for dismantling purposes, though it is early yet to determine their fate, as certain propositions are being considered which may result in the running of part, if not the whole, of the works. The concern was old-established and became a limited company in 1909 under the style of the Carbrook Steelworks, Limited. In addition to the steel furnaces, the plant consists of three bar mills with forge and five steam hammers. A special production has been hollow-cored mining drill steel.

MR. SYDNEY EVANS, of 22/23, Laurence Pountney Lane, London, E.C.4, has been appointed London and Southern Counties representative for Messrs. Beecroft & Partners and their subsidiary company, Messrs. Sulron. It will be recalled that, in addition to acting as the general manager for the U.K., he is also the sales representative of Messrs. Pittevil & Company for London and the Southern Counties. These principals are the main sales distributors for Messrs. Ketin et Thiriart, manufacturers of the Ketin patented sand-preparing plant; Mr. Ivan Lamoureux, a pioneer manufacturer of mould-drying plant; and also Messrs. "Silica," proprietors of the well-known Belgian moulding sand. They are also actual manufacturers of moulding machines to the well-known Wardle patents, and are now free to offer these Belgian-made machines for sale in England.

Dundee Foundry to Close.

One of the oldest iron-foundry firms in Scotland, Messrs. James Carmichael & Company, Limited, Dundee, has decided to close down. Founded over a century ago, it had at its head for many years Mr. James Carmichael, an inventor with a world-wide reputation. Recently the firm was reorganised, but trade showed little or no improvement, and the services of the employees have been gradually dispensed with.

Contracts Open.

Ayr, January 23.—8,800 ft. of 24-in. diam. and 5,800 ft. of 21-in. diam. bitumen-lined steel pipes, for the Corporation. Messrs. Warren & Stuart, 94, Hope Street, Glasgow. (Fee £2 2s., returnable.)

Chorley, January 22.—Cast-iron pipes, for the Corporation. The Borough Surveyor. (Fee £2 2s., returnable.)

Johannesburg, February 14.—Wheels and axles, for the South African Railways and Harbours (Tender No. 1390). The Department of Overseas Trade. (Reference A.X. 7329.)

Liverpool, February 7.—Wrought-iron lamp standards, brackets, etc., cast-iron lamp columns and pitching irons. The City Lighting Engineer, 17, Highfield Street, Liverpool.

London, E.C., February 16.—Pipes, etc., for the Metropolitan Water Board. The Chief Engineer, Offices of the Board, 173, Rosebery Avenue, Clerkenwell, E.C.1.

London, S.E., January 30.—Steel sleepers, cast-iron sleeper plates and distance-pieces, mild-steel gibs, cotters and keys, steel tiebars, and 46 locomotive boilers, for the India Store Department, Belvedere Road, Lambeth, London, S.E.1. (Fee 5s. each, non-returnable.)

New Delhi, January 30.—Sleepers and fittings, for the Railway Department, New Delhi. The Department of Overseas Trade. (Reference A.X. 7339.)

Dewsbury, January 21.—Valves, penstocks and other ironwork, for the Town Council. Messrs. J. Diggle & Son, Hind Hill Street, Heywood, Lancashire. (Fee £1 1s., returnable.)

Personal.

MR. E. A. MITCHELL-INNES, K.C., has resigned from the board of Messrs. Guest, Keen & Nettlefolds, Limited, the demands of his legal work having made this step necessary.

MR. JOHN R. HOPE, who was formerly with Messrs. Sir W. G. Armstrong, Whitworth & Company, Limited, has joined the Partington Steel & Iron Company, Limited, Irlam, Manchester, as general sales manager.

We are informed that Mr. John A. Smeeton, M.I.Mech.E., has resigned from his position as Managing Director of the British Perlit Iron Company, Limited, of 15, Victoria Street, London, S.W.1. He will still remain a director of the company. The registered offices of the company have been removed to Liverpool, and the address in future will be the British Perlit Iron Company, Limited, 9, Rumford Street, Liverpool. Mr. T. K. Moulsdale has been appointed secretary and Mr. F. Grimshaw Martin, B.Sc., F.I.C., as technical manager. In future all communications should be sent to the new address.

Wills.

RUTTER, R. V., Northam, retired blacksmith	£5,498
WHITE, F., of Oxford Road, Middlesbrough, retired engineer	£6,836
HORSFIELD, J., of Bradford, iron manufacturer	£7,189
KENNEDY, SIR ALEXANDER B. W., consulting civil and electrical engineer	£90,909
RAMSDEN, SIR WILLIAM, of Marshfield, Huddersfield, a director of Hopkinsons, Limited, engineers and founders ...	£29,790
BOOTH, R., Hazehead Hall, near Penistone, director and manager of the Hepworth Iron Company, Limited	£1,934
COHEN, M. E., of Fitzjohn's Avenue, Hampstead, and Commercial Road, London, E., metal and machinery merchant ...	£159,446
STEDALL, H., of The Old House, Farnham Royal, Bucks., and Kensington Court, London, W., largely interested in Stedall & Company, Limited, iron, steel and metal merchants	£201,243

New Companies.

Interwood, Limited.—Capital £500. Ironfounders, etc. Solicitor: H. Kenwright, 16, Hendrick Avenue, London, S.W.

Beasley Valves, Limited.—Capital £1,000 in 1s. shares. Founders, engineers, etc. Directors: W. R. Smith, L. W. Farrow, A. W. Mills and T. Beasley, 33, Narbonne Avenue, London, S.W.

Gabriel & Company, Limited, 4 and 5, A.B. Row, Birmingham.—Capital £12,500 in £1 shares. Brassfounders, etc. Directors: Margaret, E. P. (managing director), J. C. F., Mary V. T., and Constance M. P. Gabriel.

Obituary.

THE DEATH has taken place of Mr. James Davie, of Messrs. James Davie & Sons, Stirling Foundry, Orchard Place, Stirling.

MR. FREDERIC ISIDOR SANDERSON, a director of the Wellman Smith Owen Engineering Corporation, Limited, died recently at his home in Claygate, Surrey.

MR. J. C. LLOYD, chief engineer to the Great Western Railway Company, a position to which he was appointed on January 1, 1926, died recently at Reading.

HERR OTTO GRUSON, the well-known German ironmaster and head of the Gruson Works, which were founded by his father, has died in Magdeburg, at the age of 65.

THE DEATH took place, in Stirling Royal Infirmary, on Friday, December 28, after a lingering illness, of Mr. James Wright. He was a native of Stirling, served his time in Bannockburn, and was employed by the Falkirk Iron Company for many years.

KARL EMIL JOSEF PAUL BARON SKODA, son of the founder of the famous Skoda armament works at Pilsen, in Bohemia, has died at Semmering, aged 51. Baron Skoda was general manager of the Skoda works during the war.

MR. WILLIAM PERROT, J.P., a director of the Lilleshall Company, Limited, has died at Bridgnorth at the age of 81 years. Mr. Perrott was appointed general manager of the Lilleshall Company in 1882, and was elected a director in 1913. Later he was made deputy chairman, which appointment he retained until a few months ago. Mr. Perrott was one of the best-known members of the Birmingham Iron and Steel Exchange. In addition to his connection with the Lilleshall Company he was also chairman of Messrs. C. & W. Walker, Limited, of Donnington.

Students' Corner

Q.—What is the origin of naturally-bonded foundry sands?

A.—Sand is formed by natural decomposition of granite rock and consists, more or less, of three distinct substances: (1) Quartz, which is practically pure silica sand. This constituent gives refractoriness to the sand; (2) Clay, which is aluminium oxide and silica combined together forming (hydrated) silicate of alumina, and is the constituent responsible for the bonding quality; and (3) Felspars, which consist of combinations of sodium and potassium oxides, lime, magnesia, together with some silica and alumina, but these are deleterious substances as they reduce the refractoriness (heat-resistance) of the sand. They are the undecomposed part of the rock, and tend to form fusible slags under the action of the molten metal.

Applications for Trade Marks.

"ZAMAK."—A zinc-base alloy. The New Jersey Zinc Company, c/o Feeny & Feeny, 73A, Queen Victoria Street, London, E.C.4.

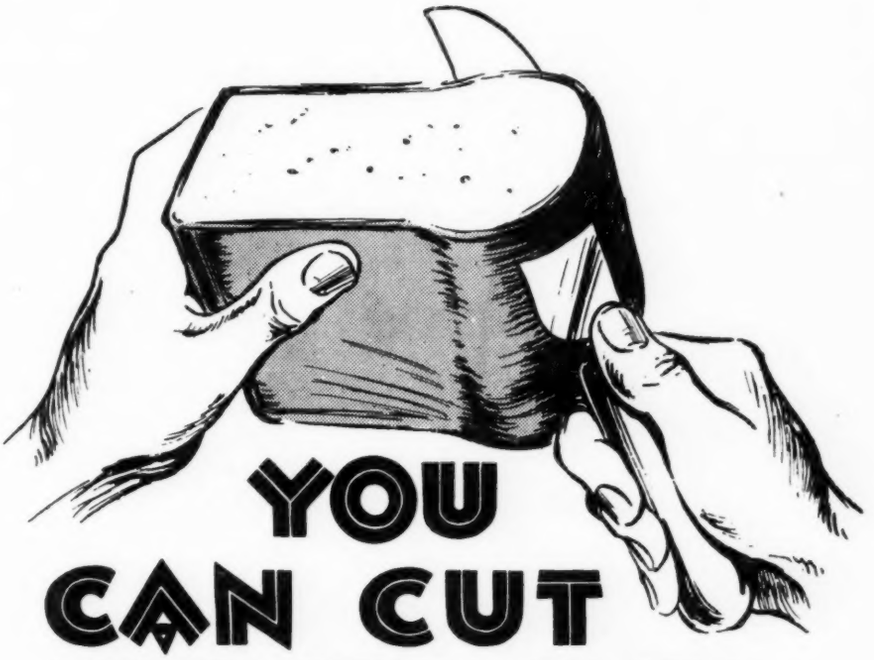
"OXYPET."—Welding apparatus. Hancock & Company (Engineers), Limited, Aurelia Road, Croydon.

"GROBESTOS."—Steam jointing. Grosvenor & Company (London), Limited, 7 & 9, Creechurch Lane, London, E.C.3.

Publication Received.

Nickel Cast Iron.—The Bureau of Information, Limited, of 2, Metal Exchange Buildings, London, E.C.3, in their publication Series B, No. 5, have reprinted Prof. D. Hanson's Paper, read before the Institute of British Foundrymen, on the above subject. As it is uniform with the balance of their brochures, it renders the filing of so useful a Paper a light and worth-while task. We understand that these brochures are available for our readers on application.

THE PARTNERSHIP between Messrs. C. H. Bloore and P. E. Piller, carrying on business as brassfounders, at Unett Street, Hockley, Birmingham, under the style of Bloore & Piller, has been dissolved. Mr. P. E. Piller is continuing the business.



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Iron and Steel Markets.

Pig-Iron.

MIDDLESBROUGH.—As anticipated in recent reports, increased interest on the part of consumers is developing steadily, and at this week's Cleveland iron market, with stocks in hand now barely sufficient for local needs, it was realised that an early addition to the number of furnaces in blast in the Tees-side area must claim the immediate attention of ironmasters. In market circles the position will amply justify an increase of output of both foundry and hematite pig, home demands progressing on an expanding scale, while the export trade gives promise of a similar movement, with inquiries much more numerous than has been experienced for many months, if not a longer period. Moreover, lower railway rates have slightly reduced works' costs, and ironmasters may be less averse to resuming the production of foundry iron for the open market so soon as the demand seems to justify this step. Present signs are that that period will not be much longer delayed, as indicating an improvement in home industrial requirements. Prices meanwhile are firm and steady, No. 1 Cleveland foundry iron being quoted at 68s. 6d. per ton for home and export, No. 3 G.M.B. pig-iron at 66s., No. 4 foundry at 65s., and No. 4 forge at 64s. 6d. per ton.

With increased activity in the shipbuilding industry, the demand from steelworks for hematite supplies is further expanding, and it appears probable that an extension of outputs will be necessary to meet current requirements and pressing calls for delivery on all hands. Prices are also firmer, current quotations now ruling at 71s. for East Coast mixed numbers and 71s. 6d. for No. 1 quality. On the North-West Coast Bessemer prices also remain firm at 71s. per ton at works.

LANCASHIRE.—Very few new contract orders for foundry pig are reported at this week's local markets, but the tendency of prices is steady, with Derbyshire No. 3 for delivery in this area quoted at about 68s. per ton, Staffordshire at 67s. 6d., Cleveland at about 79s., and Scottish at from 87s. 6d. to 90s., according to quantity and brand.

THE MIDLANDS.—A slight improvement in demand for foundry pig has developed of late in the South Staffordshire area. Some of the makers of light castings and those engaged on small electrical parts are busier, and are under the impression that conditions will show still further progress in the next month or two. Meanwhile, prices are firm, as follow: Northamptonshire, 55s. to 56s.; Derbyshire No. 3, 59s. to 60s.; and North Staffordshire, 60s. to 61s., at furnaces.

SCOTLAND.—The markets for Scottish foundry pig continue quiet, with prices unchanged. In addition to the general slackness of trade, labour troubles have arisen among the light-castings moulders, and also among the malleable workers. In the former case over 1,000 men are on strike in the Falkirk area over the question of a proposed 5 per cent. reduction in wages.

Finished Iron.

There is very little improvement in the demand for crown and nut and bolt iron, and the mills can only work spasmodically; nor is any immediate prospect of betterment observable. The local ironworks continue to find very keen competition from Lancashire and Derbyshire, and better prices are quite impossible while this state of affairs exists. Crown iron is quoted at £9 to £9 5s., and bolt iron at from £8 12s. 6d. to £8 17s. 6d. per ton. There is no change in the price of marked bars, which are quoted at £12 at makers' works. The mills are fairly well occupied with orders for this grade of iron, and are looking forward to improved conditions.

Scrap.

So far as can be observed, the improvement in demand for most qualities of foundry material has not yet extended to the scrap metal section, which continues quiet and uneventful in most markets under notice. In the Tees-side area a local foundry strike has helped to keep the heavy cast-iron market inanimate, and 60s. per ton for ordinary quality and 65s. for machinery quality are the best prices obtainable. In the Midlands there is a fairly good demand for heavy cast-iron scrap. Prices vary from 62s. 6d. to 65s. delivered, according to the quality of the material. Light cast-iron scrap is scarce, 52s. 6d. to 55s. delivered being quoted. In Scotland the cast-iron scrap market has not yet brightened, and the foundries are still limiting their purchases. Heavy machinery cast-iron scrap, in pieces not exceeding 1 cwt., is still quoted at 65s. to 66s., with heavy ordinary cast iron to the same specification at 60s. to 61s. Light cast-iron scrap is 57s. 6d. to 58s. The above prices are all per ton, delivered f.o.t. consumers' works.

Steel.

At Sheffield this week markets are generally quiet as concerns semi-products, with only a restricted demand for Siemens acid billets, and the quotation for these has fallen to £8 15s. Basic billets are rather less freely bought at the moment, but prices are unchanged at £6 12s. 6d. for soft, £6 17s. 6d. for semi-hard, £7 12s. 6d. for medium hard, and £8 12s. 6d. for hard. The call for wire rods is one of the best features. Prices of these have been more or less in a state of flux for some time, but there are indications of some sort of fixation before long. Present quotations are:—Soft basic, £7 12s. 6d.; medium hard, £9 5s.; hard, £10 10s.; and acid, £12. In the tinplate market makers are standing to their quotations, which range as follow:—Coke tinplates, 18s. to 18s. 3d. basis, net cash, f.o.b. Welsh ports.

Metals.

Copper.—Values of warrant copper continue unchecked in the progressive advance noted in recent reports, and now range at levels of £75 and upwards, as contrasted with £61 for the corresponding period in 1928. The strong position of the metal must doubtless be attributed to the much larger buying having been deferred, due to consumers assuming that the big increase of production of the past few months would quickly relieve the tension on the market. Demand seems to have expanded almost as rapidly as primary supplies, however, and faster than the supply of refined metal.

Closing quotations are:—

Cash.—Thursday, £75 5s. to £75 6s. 3d.; Friday, £75 10s. to £75 12s. 6d.; Monday, £75 to £75 2s. 6d.; Tuesday, £74 12s. 6d. to £74 15s.; Wednesday, £74 12s. 6d. to £74 15s.

Three Months. — Thursday, £73 11s. 3d. to £73 12s. 6d.; Friday, £73 12s. 6d. to £73 13s. 9d.; Monday, £73 to £73 1s. 3d.; Tuesday, £72 16s. 3d. to £72 17s. 6d.; Wednesday, £72 17s. 6d. to £72 18s. 9d.

Tin.—Although closing last week with a small advance in standard cash, the market for tin remains far from stable, and fluctuating values may be expected for some time to come. At the moment it would appear that supplies of tin are adequate to meet all normal requirements, and the heavy tonnage which is being held off the market, instead of assisting, serves only to aggravate the situation further. Good deliveries of tin are anticipated, and the possibility of a decreasing tendency in the visible supply over the next three months is not improbable.

Official closing prices:—

Cash.—Thursday, £223 5s. to £223 10s.; Friday, £224 to £224 2s. 6d.; Monday, £222 10s. to £222 12s. 6d.; Tuesday, £222 15s. to £222 17s. 6d.; Wednesday, £223 to £223 2s. 6d.

Three Months.—Thursday, £223 5s. to £223 10s.; Friday, £223 17s. 6d. to £224; Monday, £222 10s. to £222 15s.; Tuesday, £222 2s. 6d. to £222 5s.; Wednesday, £222 2s. 6d. to £222 5s.

Spelter.—The condition of the market still remains uncertain. Business with consumers has been well sustained, and the amount of actual business concluded has been fairly good when the period of the year is considered. The anxiously awaited information regarding the agreement reached by consumers in Brussels is still not forthcoming.

Daily quotations are:—

Ordinary.—Thursday, £26 7s. 6d.; Friday, £26 6s. 3d.; Monday, £26 5s.; Tuesday, £25 17s. 6d.; Wednesday, £26.

Lead.—Although consumptive demand for soft foreign pig has been rather slack of late, the London market continues fairly active. Heavy arrivals during the last few weeks have been well absorbed, but, as evidenced by a recent setback, the advance may have been too rapid. Consumers are not covered for very far ahead, and a continuation of the buying movement may be expected. Indications at the moment are in favour of a maintenance of higher price levels.

Prices have been:—

Soft Foreign Prompt.—Thursday, £22 1s. 3d.; Friday, £22; Monday, £21 17s. 6d.; Tuesday, £21 15s.; Wednesday, £22.

Patent Specifications Accepted.

The following list of Patent Specifications accepted has been taken from the "Illustrated Official Journal (Patents)." Printed copies of the full Specifications are obtainable from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each. The last numbers given are those under which the Specifications will be printed and abridged, and all subsequent proceedings will be taken.

19,758. POCOCK, A. L. Manufacture of white alloys. 299,493.

19,924. HODGSON, F., and WESTINGHOUSE BRAKE & SAXBY SIGNAL COMPANY, LIMITED. Foundry moulding machines. 299,498.

19,994. SMITH, W. S., GARNETT, H. J., and HOLDEN, J. A. Iron alloys. 299,502.

20,103. WILLIAMS, S. Rolling mills. 299,510.

20,219. BEATTY, W. E. (Bell Telephone Laboratories, Inc.). Wire-drawing apparatus. 299,523.

20,222. ZAIDAN HOJIN RIKAGAKU KENKYUJO. Preparing pure alumina. 284,661.

20,230. HANDSTOCK, LIMITED, and AVERY, F. Electric welding apparatus. 299,524.

20,298. ELEY, C. V. A. Furnaces. 299,527.

20,317. SCHIESS, H. J., BOITEL, A. C., ZACHNER, E., BOITEL, A., and SCHIESS, H., [trading as ZAHNER & SCHIESS & COMPANY]. Lead coating of articles. 276,643.

20,387. WARREN, A. I. GATES-, WARREN, E. L. GATES-, and PRECIOUS METAL INDUSTRIES, LIMITED. Coating non-conducting substances with metals. 299,903.

20,422. STEPHENS, F. G. C., ANDERSON, L. J., and CASH, W. A. Manufacture of titanium oxide. 299,835.

20,827. EVANS, A. J. Utilisation of waste iron pickle. 299,919.

22,386. DOVEL, J. P. Blast furnaces. 299,941.

33,936. NAYLOR, G. W., NAYLOR, J. F., NAYLOR, W., and NAYLOR, C. E. Ingot moulds. 300,033.

1,414. ROECKNER, M. Apparatus for rolling tubes from hollow metal blocks. 285,896.

5,971. DEMAG AKT.-GES. Apparatus for charging tilting smelting furnaces. 286,224.

10,015. HALL, H. C., and BRADBURY, T. F. Aluminium alloy. 300,078.

17,884. NEELY NUT AND BOLT COMPANY. Apparatus for making bolts and screws. 294,201.

25,600. LINDHORST, H. Hardening of iron, mild steel, and iron alloys. 302,740.

1,564. CENTRIFUGAL CASTINGS, LIMITED. HURST, J. E., and BALL, E. B. Apparatus for extracting pipes, moulds, etc. 302,821.

10,300. ASHCROFT, E. A. Metallurgy of ores or materials containing tin. 302,851.

19,926. BERTLEFF, DR. V. Pickling of iron and steel. 293,701.

Iron and Steel Production.

The National Federation of Iron and Steel Manufacturers, in their Statistical Bulletin for November, state that the slight increase in the production of pig-iron and steel recorded in October was continued in November, pig-iron production increasing from 543,600 tons to 544,400 tons, an increase when the shorter month is taken into account of four per cent., while steel production increased from 756,000 tons in October to 762,500 tons in November.

Channel Steel Company, Limited.—SIR HUGH BELL, Bt., presided at the twelfth annual meeting of the Channel Steel Company, Limited, held recently, when the report and accounts were adopted. Replying to questions by a shareholder, Sir Hugh Bell said that until they were more certain of the quality of their coal for the purpose of steel making, it would be futile to open beds. They had a valuable property, but a large amount of money would be taken to develop it.

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R
TRADE MARK

IRON & STEEL CEMENTS

AWARDED DIPLOMAS and MEDALS by the ROYAL SANITARY INSTITUTE, LONDON.

3 GRADES

ALL BRITISH CEMENTS

A
WHITE LABEL

B
BLUE LABEL

C
RED LABEL

Full particulars upon request.

Sole Manufacturers—
MAJOR, ROBINSON & Co. Ltd.
385 & 387, CITY RD., CORNBROOK,
MANCHESTER.
'Phone: Trafford Pk. 1760 Telegrams: "Blowpipe, Manchester."

BRADLEY FACTS FOR FOUNDRYMEN NO. 1

ANALYSIS

In the manufacture of high grade castings the chemical composition of the pig iron used is important. Uniformity of analysis from one consignment to another is necessary.

BRADLEY'S IRON IS ANALYSED BEFORE DESPATCH

For the convenience of Ironfounders who have no metallurgical staff, Bradley's supply complete figures for making up perfect mixtures to suit specific requirements.

Bradley's REFINED
PIG IRON

"A QUALITY FOR EVERY REQUIREMENT"

BRADLEY & FOSTER, LIMITED
DARLASTON, STAFFS.
And at Capponfield, Bilston.
TELEPHONE: DARLASTON, 16. (Private Branch Exchange)
TELEGRAMS: BRADLEY'S, DARLASTON.

ARE YOU TROUBLED WITH GASES FROM YOUR CORES?
IF SO, REMOVE THIS TROUBLE BY USING

BRITAIN'S CORE BINDER
"CUMMINGUM"

A BINDING PROPOSITION THAT IS A PLEASURE TO USE, GIVES GREATER PRODUCTION WITH EFFICIENCY, SAVES TIME, WORRY, MONEY, AND, LASTLY, GIVES OFF NO OBNOXIOUS FUMES.

Wm. Cumming & Co., Ltd.

Glasgow - Falkirk - Chesterfield - Deepfields - Middlesbrough

Always at your Service. *Send for Sample.* *Stocks at all Branches.*

WEEKLY PRICE CURRENT.

COPPER.

	£ s. d.
Standard cash	74 12 6
Three months	72 17 6
Electrolytic	78 5 0
Tough	76 5 0
Best selected	76 15 0
Sheets	102 0 0
India	86 15 0
Wire bars	78 12 6
Do. January	78 12 6
Do. February	78 12 6
Ingot bars	78 12 6
H.C. Wire rods	82 15 0
Off. av. cash, December	69 7 7 5/7
Do. 3 mths., December	69 4 4½
Do., Sttlmnt., December	69 7 7 1/7
Do., Electro, December	75 4 10 7/7
Do., B.S., December	73 16 10½
Aver. spot price, copper, Dec.	69 7 7 3/7
Do. Wire bars, December	75 9 8 1/2
Solid drawn tubes	14½d.
Brazed tubes	14½d.
Wire	10½d.

BRASS.

Solid drawn tubes	12½d.
Brazed tubes	14½d.
Rods, drawn	11½d.
Rods, extd. or rlld.	7½d.
Sheets to 10 w.g.	10½d.
Wire	10½d.
Rolled metal	10½d
Yellow metal rods	7½d.
Do. 4 × 4 Squares	8d.
Do. 4 × 3 Sheets	8½d.

TIN

Standard cash	223 0 0
Three months	222 2 6
English	223 0 0
Bars	224 15 0
Straits	224 2 6
Australian	223 15 0
Eastern	224 7 6
Banca	223 12 6
Off. av. cash, December	227 13 11 7/10
Do., 3 mths., December	226 8 3 7/10
Do., Sttlmt., December	227 12 10 4/10
Aver. spot, December	227 13 11 7/10

SPELTER.

Ordinary	26 0 0
Remelted	24 15 0
Hard	20 0 0
Electro 99.9	28 10 0
English	26 5 0
India	21 10 0
Zinc dust (Nom.)	36 10 0
Zinc ashes	8 5 0
Off. aver., December	26 12 2 1/10
Aver., spot, December	26 12 2 1/10

LEAD.

Soft foreign ppt.	22 0 0
English	23 5 0
Off. average, December	21 10 8 1/10
Average spot, December	21 6 10 7/10

ZINC SHEETS, &c.

Zinc sheets, English	34 5 0
Do. V.M. ex whf.	33 10 0
Rods	44 0 0
Boiler plates	32 0 0
Battery plates	33 0 0

ANTIMONY.

Special brands, Eng.	54 10 0
Chinese	37 15 0
Crude	33 10 0

QUICKSILVER.

Quicksilver	22 5 9

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—	
25%	7 17 6
45/50%	12 0 0
75%	19 0 0
Ferro-vanadium—	
35/50%	14/- lb. Va.
Ferro-molybdenum—	
70/75% c. free	4/3 lb. Mo.
Ferro-titanium—	
23/25% carbonless	1/- lb.
Ferro-phosphorus, 20/25%	£18 0 0
Ferro-tungsten—	
80/85%, c. fr.	1/5 lb.
Tungsten metal powder—	
98/99%	1/10 lb.
Ferro-chrome—	
2/4% car.	£30 10 0
4/6% car.	£21 12 6
6/8% car.	£20 12 6
8/10% car.	£20 7 6
Ferro-chrome—	
Max. 2% car.	£33 0 0
Max. 1% car.	£37 0 0
Max. 0.70% car.	£44 0 0
70% carbonless	1/- lb.
Nickel—99% cubes or pellets	£175 0 0
Ferro-cobalt	9/- lb.
Aluminium 98 99%	£95 0 0
Metallic chromium—	
96/98%	2/6 lb.
Ferro-manganese (net)—	
76/80% loose	£13 15 0
76/80% packed	£14 15 0
76/80% export	£14 10 0
Metallic manganese—	
94/96%, carbonless	1/6 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	£0 2 3
Finished bars, 18% tungsten	£0 2 9

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to ⅛ in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ¼ in. × ⅛ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

Scrap from high-speed tool steel—	
Scrap pieces	3d.
Turnings and swarf	1d.

Per lb. net, d/d steel makers' works.

SCRAP.

	£ s. d.
South Wales—	
Hvy. steel	3 10 0
Bundled steel and shrngs.	3 4 0 to 3 8 6
Mixed iron and steel	3 3 0 to 3 4 0
Heavy cast iron	2 17 0 to 2 18 0
Good machinery for foundries	3 0 0
Cleveland—	
Heavy steel	3 1 6
Steel turnings	2 8 6
Cast iron borings	2 4 0
Heavy forge	3 7 6
W.I. piling scrap	3 0 0
Cast-iron scrap	3 1 0 to 3 5 0
Lancashire—	
Cast-iron scrap	2 12 6 to 3 5 0
Hvy. wrought	3 7 6
Steel turnings	2 5 0

London—Merchants' buying prices delivered yard.

Copper (clean)	57 0 0
Brass	39 0 0
Lead (less usual draft)	19 10 0
Tea lead	16 10 0
Zinc	17 0 0
New aluminium cuttings	67 0 0
Braziery copper	52 0 0
Gunmetal	50 0 0
Hollow pewter	150 0 0
Shaped black pewter	105 0 0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast—	
Foundry No. 1	68/6
Foundry No. 3	66/-
Foundry No. 4	65/-
Forge No. 4	64/6
Hematite No. 1	71/6
Hematite M/Nos.	71/-
N.W. Coast—	
Hem. M/Nos. d/d Glas.	78/-
,, d/d Birm.	85/6
Midlands—	
Staffs. common*	67/6
,, No. 4 forge	56/-
,, No. 3 fdry.	60/-
Shrops. basic	—
,, Cold blast, ord.*	—
,, ,, roll iron*	—
* d/d Birmingham.	
Northants forge	52/-
,, fdry. No. 3	55/-
Derbyshire forge	59/-
,, fdry. No. 3	60/-
,, basic	65/-
Scotland—	
Foundry No. 1	75/-
,, No. 3	70/-
Hem. M/Nos.	75/-
Sheffield (d/d district)—	
Derby forge	61/6
,, fdry. No. 3	64/-
Lincs. forge	62/6
,, fdry. No. 3	65/6
E.C. hematite	80/-
W.C. hematite	82/6
Lincs. (at furnaces)—	
Forge No. 4	58/-
Foundry No. 3	61/-
Basic	60/-
Lancashire (d/d eq. Man.)—	
Derby forge	—
,, fdry. No. 3	68/-
Northants foundry No. 3	—
Dalzell, No. 3(special)	100/- to 102/6
Summerlee, No. 3	87/6 to 90/-
Glengarnock, No. 3	87/6 to 90/-
Gartsherrie, No. 3	87/6 to 90/-
Monkland, No. 3	87/6 to 90/-
Shotts, No. 3	87/6 to 90/-

FINISHED IRON AND STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£ s. d.	£ s. d.
Bars (cr.) nom.		10 5 0
Nut and bolt iron	8 12 6 to 8	17 6
Hoops		11 10 0
Marked bars (Staffs.) f.o.t.		12 0 0
Gas strip		11 10 0
Bolts and nuts, ½ in. × 4 in.		15 5 0
Steel—		
Ship plates	8 7 6 to 8	12 6
Boiler plts.		10 10 0
Chequer plts.		10 12 6
Angles		7 17 6
Tees		8 17 6
Joists		7 17 6
Rounds and squares, 3 in. to 5½ in.		8 17 6
Rounds under 3 in. to ½ in. (Untested)		7 15 0 and upwards
Flats, over 5 in. wide and up		8 7 6
Flats, 5 in. to 1½ in.		7 17 6
Rails, heavy		8 10 0
Fishplates		12 10 0
Hoops (Staffs.)		10 10 0
Black sheets, 24g.	10 0 0 to 10	10 0
Galv.cor.shts..24g.	13 7 6 to 13	12 6
Galv. fencing wire 8g. plain		12 10 0
Billets, soft	6 5 0 to 6	12 6
Billets, hard	7 5 0 to 7	12 6
Sheet bars		6 0 0
Tin bars		8 0 0

PHOSPHOR BRONZE.

	Per lb. basis
Strip	1 3
Sheet to 10 w.g.	1 3½
Wire	1 4½
Rods	1 3½
Tubes	1 8
Castings	1 2½

Delivery 3 cwt. free.
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/3½ to 1/9½
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4½ to 1/10½
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks	9d. to 1/5½
Ingots rolled to spoon size	1/- to 1/8½
Wire round—	
3/0 to 10 G. with extras according to gauge.	1/6½ to 2/1½

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2X foundry, Phila.	21.26
No. 2 foundry, Valley	18.00
No. 2 foundry, Birm.	16.50
Basic	19.26
Bessemer	20.79
Malleable	20.01
Grey forge	19.26
Ferro-mang. 80% d/d	105.00
O.-h. rails, h'y at mill	43.00
Bess billets	33.00
O.-h. billets	33.00
O.-h. sheet bars	33.00
Wire rods	42.00
	Cents.
Iron bars, Phila.	2.12
Steel bars	1.95
Tank plates	1.90
Beams, etc.	1.90
Skelp, grooved steel	1.90
Skelp, sheared steel	1.90
Steel hoops	2.20
Sheets, black, No. 24	2.85
Sheets, galv., No. 24	3.60
Sheets, blue an'l'd, 9 and 10	2.10
Wire nails	2.65
Plain wire	2.50
Barbed wire, galv.	3.30
Tinplates, 100 lb. box	$5.35

COKE (at ovens)

Welsh foundry	—
,, furnace	—
Durham and North.	
,, foundry	16/-
,, furnace	14/6
Midlands, foundry	—
,, ,, furnace	13/- to 14/6

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes	20×14 box		18/-
,,	28×20	,,	36/-
,,	20×10	,,	26/3
,,	18¾×14	,,	18/9
C.W.	20×14	,,	15/-
,,	28×20	,,	33/6
,,	20×10	,,	21/3
,,	18¾×14	,,	15/-
Terneplates	28×20		33/6 per box basis f.o.b.

SWEDISH CHARCOAL IRON & STEEL.

Pig-iron	£6 0 0 to £7 10 0
Bars, hammered, basis	£17 10 0 to £18 10 0
Bars & nailrods, rolled, basis	£15 15 0 to £16 15 0
Blooms	£10 0 0 to £12 0 0
Keg steel	£32 0 0 to £33 0 0
Faggot steel	£20 0 0 to £24 0 0
Bars & rods, dead soft, steel	£10 0 0 to £14 0 0

All per English ton, f.o.b. Gothenburg

TUBES AND FITTINGS.

Up to and incl. 6 in.

	Tubes.	*Fittings.*
Gas	67½%	50%
Water	63⅓%	45%
Steam	60%	40%

W.I. 10% extra.

DAILY FLUCTUATIONS.

Standard Copper (cash).

		£	s.	d.	
Jan. 10		75	5	0	inc. 5/-
,, 11		75	10	0	,, 5/-
,, 14		75	0	0	dec. 10/-
,, 15		74	12	6	,, 7/6
,, 16		74	12	6	No change

Electrolytic Copper.

		£	s.	d.	
Jan. 10		78	5	0	No change
,, 11		78	5	0	,, ,,
,, 14		78	5	0	,, ,,
,, 15		78	5	0	,, ,,
,, 16		78	5	0	,, ,,

Standard Tin (cash).

		£	s.	d.	
Jan. 10		223	5	0	dec. 57/6
,, 11		224	0	0	inc. 15/-
,, 14		222	10	0	dec. 30/-
,, 15		222	15	0	inc. 5/-
,, 16		223	0	0	,, 5/-

Tin (English ingots).

		£	s.	d.	
Jan. 10		223	5	6	dec. 50/-
,, 11		224	0	0	inc. 15/-
,, 14		222	10	0	dec. 30/-
,, 15		222	15	0	inc. 5/-
,, 16		223	0	0	,, 5/-

Zinc Sheets (English).

		£	s.	d.	
Jan. 10		34	10	0	dec. 10/-
,, 11		34	5	0	,, 5/-
,, 14		34	5	0	No change
,, 15		34	5	0	,, ,,
,, 16		34	5	0	,, ,,

Spelter (ordinary).

		£	s.	d.	
Jan. 10		26	7	6	dec. 5/-
,, 11		26	6	3	,, 1/3
,, 14		26	5	0	,, 1/3
,, 15		25	17	6	,, 7/6
,, 16		26	0	0	inc. 2/6

Lead (English).

		£	s.	d.	
Jan. 10		23	10	0	No change
,, 11		23	10	0	,, ,,
,, 14		23	5	0	dec. 5/-
,, 15		23	5	0	No change
,, 16		23	5	0	,, ,,

Exports of Iron Castings in December and the twelve months 1928, compared with December and the twelve months 1927.

	December, 1927.	December, 1928.	Twelve months, 1927.	Twelve months, 1928.	December, 1927.	December, 1928.	Twelve months, 1927.	Twelve months, 1928.
BUILDERS' CASTINGS—								
Stoves, Grates, etc., Cisterns, Baths, etc., and cooking and washing boilers:—	Tons.	Tons.	Tons.	Tons.	£	£	£	£
To Argentine Republic	137	121	1,593	1,812	4,198	4,185	58,519	72,971
,, British South Africa	316	539	3,178	3,834	11,492	17,544	114,723	132,625
,, ,, India	122	224	1,224	1,587	5,782	9,063	57,268	66,973
,, Australia	63	57	916	632	4,030	3,849	53,330	43,828
,, New Zealand	155	207	2,056	1,889	9,985	9,098	107,541	97,406
,, Other countries	864	1,265	8,961	9,928	40,390	58,352	438,263	462,942
Total	1,657	2,413	17,928	19,682	75,877	102,091	829,644	876,745
PIPES AND FITTINGS—CAST—								
To Argentine Republic	196	831	8,947	9,665	2,147	7,851	99,521	95,672
,, British South Africa	529	1,094	14,427	6,018	7,002	12,161	159,218	82,617
,, ,, India	479	394	6,884	7,570	7,499	5,665	105,383	102,979
,, Straits Settlements and Malay States	2,717	3,245	16,809	19,130	24,971	29,212	163,467	171,077
,, Ceylon	86	1,036	1,322	4,360	1,127	9,224	15,630	40,474
,, Australia	2,565	489	11,445	10,369	26,977	5,332	131,961	107,588
,, Other countries	5,046	4,961	62,905	57,681	62,623	56,039	817,478	727,905
Total	11,618	12,050	122,739	114,793	132,346	125,484	1,492,658	1,328,312
HOLLOW-WARE—								
Cast, not Enamelled, and Cast, Tinned	451	513	4,881	4,881	16,880	18,449	190,864	184,158
,, Enamelled	82	48	744	782	7,244	5,070	76,418	75,226
CASTINGS, in the rough—								
Iron	107	110	1,327	1,569	3,840	3,095	45,741	50,166
Steel	341	80	1,265	771	12,547	3,143	55,405	32,827

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(A remittance should accompany instructions.)

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Two 40"×30" Tabor Shockless rollover **£160** each
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One 24"×48" Tabor Shockless rollover **£140**
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Twelve Adaptable Moulding Machines **£16** each

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